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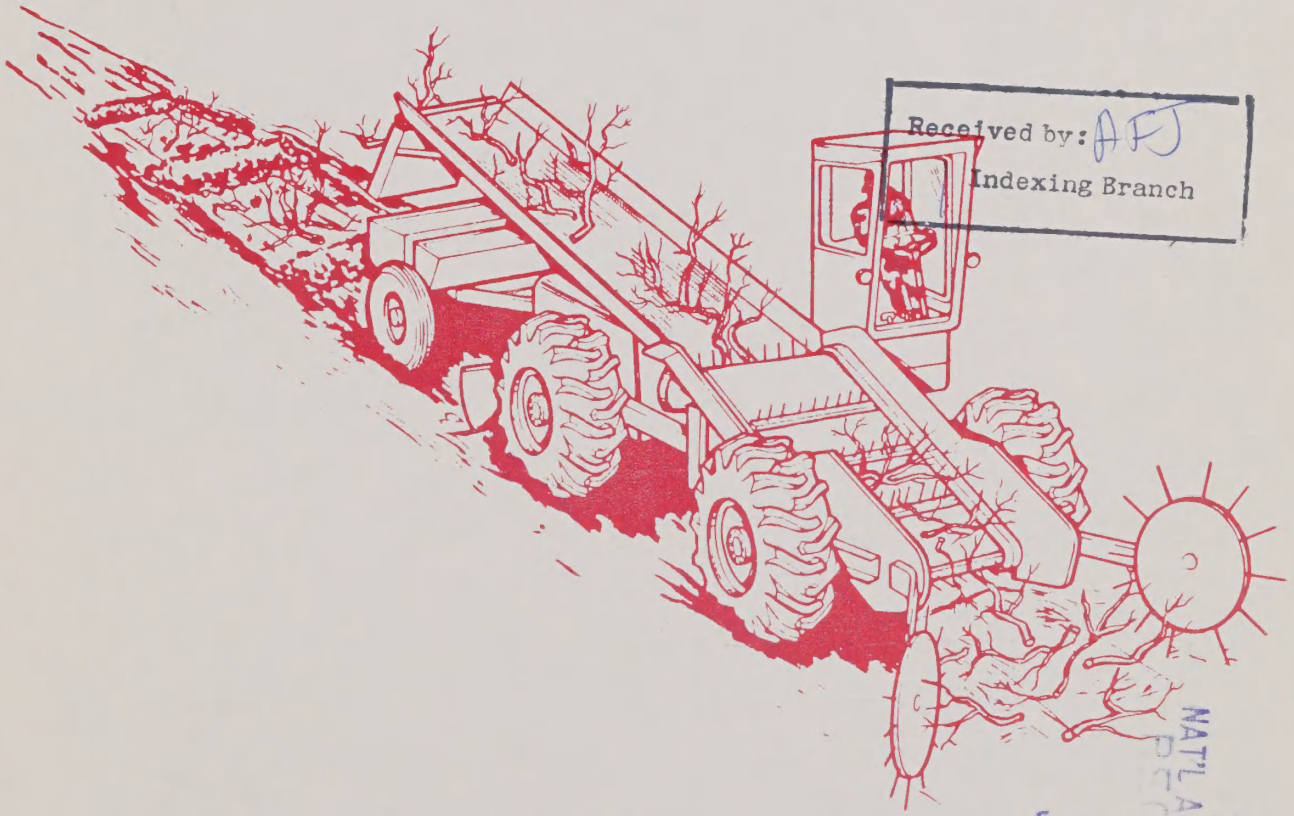
**Equipment
Development
Center**

Missoula, Mont.

San Dimas, Calif.

Vegetative Rehabilitation & Equipment Workshop

37th Annual Report
Albuquerque, New Mexico
February 13 & 14, 1983



2200—Range
8322 2804

The Vegetative Rehabilitation and Equipment Workshop is an organization of Federal and State agencies and private groups working to improve rangelands and further range equipment technology. Government officials and industry and university representatives from other countries also participate.

To accomplish its goals, the Workshop evaluates and develops equipment and prescribes specifications and standards for equipment purchase, maintenance, and use. The Workshop also functions as a clearing-house for the interchange of information and the dissemination of material describing its activities and accomplishments.

Those interested in participating in the Workshop should contact its chairman, Ray Hall, Range Management Staff, USDA Forest Service, P.O. Box 2417, Washington, D.C. 20013.

Cover: Artist's concept of a self-propelled, wheel-mounted Arid Land Seeder. A demonstration model has validated such arid land seeding. Twenty-three experimental plots in arid southern New Mexico were seeded with the demonstration model where, because of repeated failures, attempts to reestablish grass stands had been all but abandoned. Of the 23 plots, planting was considered successful on 61 percent.

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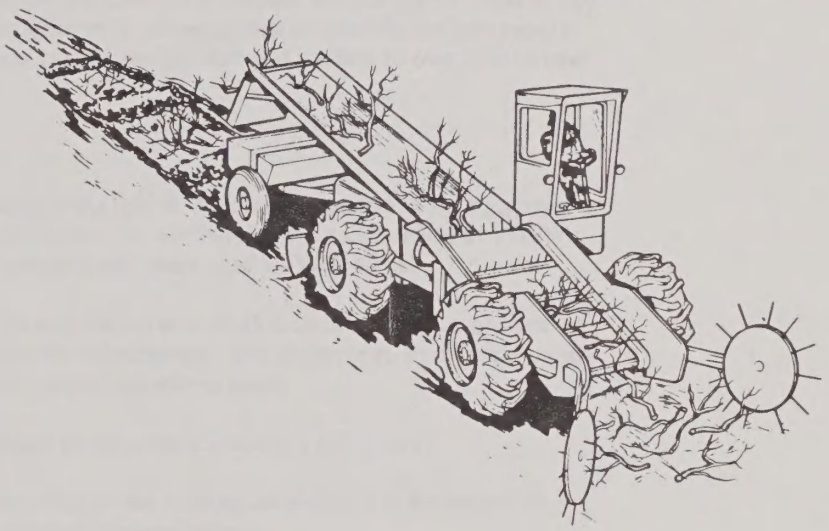

PARTICIPANTS

U.S. Department of Agriculture
U.S. Department of the Interior
State and County Organizations
State Wildlife Agencies
Industry Representatives (Chemical, Equipment, Mining, Seed)
Educational Institutions
Ranchers
Foreign Countries

October 1983

March 11, 1983

Dear Members and Friends of VREW:

This letter is a report to you on the state of the Vegetative Rehabilitation and Equipment Workshop (VREW). First, I would like to thank all people who helped make our Albuquerque Workshop a success. Special thanks go out to Ray Dalen and Darrol Harrison for arrangements, Sylvia McKenzie for registration, and to our workgroup chairmen for managing their presentations to provide the best report. Our workshop attendance was approximately 300 and swelled to over 500 to hear Allan Savory.

Role of VREW

The Steering Committee approved the role of VREW as suggested by the Exploratory Committee and your panel at the Denver workshop. This redefinition of VREW's role is dynamic and will be re-examined when needed. The role is:

The Vegetative Rehabilitation and Equipment Workshop is a forum to provide an exchange of ideas to enhance the development and dissemination of technology used in improving rangelands and surface-mined spoils.

To better identify an equipment development project, VREW may:

1. Promote an understanding of the ecology of the land to be treated as a first step in modifying or designing new equipment.

2. Use cost efficiency in evaluating proposed projects for selection.

3. Improve equipment evaluation through consultation with interested or affected Federal, State, and private organizations, and individuals.

Problem Area Investigation and Definition—Prospectus

A prospectus is a definition of a potential problem area which may suggest equipment development or modification. The purpose of a prospectus is to provide background information of a problem area that has been identified in a workgroup or to the chairmen of VREW. From preliminary investigation, the problem has been defined, previous work has been identified, conceptual analysis may be started, and funding has been proposed.

The prospectus is intended for soliciting potential interest in the problem area. When you receive a prospectus, please circulate it among your associates. We need an idea of the interest in the problem area to properly assess the future need of the proposed equipment.

VREW-SRM Ad Hoc Committee

The following report was given at the Society for Range Management (SRM) meeting in Flagstaff, Ariz., during July 1982, by the VREW-SRM Ad Hoc Committee, Ted Russell, Chairman.

Vegetative Rehabilitation and Equipment Workshop (VREW) and its predecessor, the Range Seeding Equipment Committee, have enjoyed a long (over 30 years) and mutually beneficial relationship with SRM. While neither is essential for the existence of the other, both are strengthened through this "symbiotic relationship." The great majority of VREW's annual meetings over the years have been in combination with and usually the weekend before SRM's annual meetings. While records are not available to substantiate it, this has undoubtedly brought about some increase in attendance at SRM meetings. The crowd at VREW meetings is also bolstered by interested SRM members who arrive early to attend VREW. There is strong overlap in membership.

For VREW to accomplish its goals, the workshop evaluates and develops equipment and prescribes specifications and standards for equipment purchase, maintenance, and use. The workshop also functions as a clearinghouse for the interchange of information and the dissemination of material describing its activities and accomplishments.

Society for Range Management's goals incorporate the goals of VREW and many can argue that the art and science of range rehabilitation will be enhanced if VREW joined with SRM in providing leadership for SRM concurrent sessions such as range improvements, mined-land rehabilitation, etc. All of the committee members believe that two separate organizations need to exist and that we should strive to work out scheduling conflicts with our meetings. Assuming that both organizations' objectives are to advance the range rehabilitation science, we have made the following recommendations, which we believe will advance the common objectives of both organizations:

1. VREW will continue to meet in conjunction with SRM, where possible.

2. Meeting times will continue to be Sunday and Monday mornings unless a more desirable schedule can be worked out with SRM.

3. SRM should consider a VREW representative to be a member of its annual meeting committee.

4. SRM's annual meeting committee should study the merits of inviting VREW to hold its meeting as a standing concurrent session of SRM. As a minimum, the SRM concurrent sessions for mined-land reclamation, range revegetation, and plant control should be held as close to the VREW meeting as possible. This would attract VREW participants to attend appropriate SRM concurrent sessions.

5. The program chairman for the SRM annual meeting should work with the VREW chairman in scheduling papers. Some papers are common to both meetings.

6. If a VREW registration fee is initiated (it is being studied for the purpose of financing the annual report), SRM should make an effort to help in facilitating pre-registration, management of the fee collected, and contract for the printing of an annual report, provided this is requested by VREW. The Forest Service would continue to do all prework necessary for printing.

7. Equipment being field tested should be included in the SRM summer tour.

In conclusion, the committee felt we could advance the common objectives for both organizations by working more closely together, especially through the annual convention committee and its program chairman. By implementing as many of the above recommendations as warrented, we would also enhance membership opportunities for both organizations, plus provide more interface with young range conservationists. If you need any follow-up or further explanation, please call upon any of the ad hoc members.

1983 Budget and Projects

Projects for 1983 are:

- Range Water Systems Handbook.
- Technical services provided to field units by the Missoula and San Dimas Equipment Development Centers.
- Information Workgroup support. This provides for the annual report publication.
- Problem Area Investigation and Definition—Prospectus.

Budget for 1983 is approximately $100,000.

Craig Whittekiend is our representative on the SRM annual meeting committee, and he is planning for a large attendance at what proposes to be another top Workshop. See you at Rapid City!

Sincerely,

Ted Russell

TED RUSSELL
Chairman, Vegetative Rehabilitation
and Equipment Workshop

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Monday—Feb. 14

Introductory Address: The Sahelian/Sudanian Zones of Africa: Profile of a Fragile Environment

Dr. Gerald W. Thomas, *First Vice President, Society for Range Management; President, New Mexico State University, Las Cruces, N.Mex.*

During 1980, I was authorized a leave from the presidency of New Mexico State University to conduct a study and prepare a report focusing on the food production potential of the marginal lands and semiarid regions of Africa, from Senegal to Somalia, south of the Sahara Desert. The study and preparation of a report were sponsored by the Rockefeller Foundation as part of the "Conquest of Hunger" program.

Following is a summary of the report. The full report may be obtained by writing the author or Rockefeller Foundation. Ask for *Profile of a Fragile Environment*, A Report to the Rockefeller Foundation, September 1980.

Observations and recommendations in this report are drawn from the author's professional experience, visits to several arid areas of the world, contacts with scientists and technicians in these regions, a review of selected literature, and specific field studies in the Sahelian/Sudanian zones in 1980. Previous field trips to the semidesert and desert areas to the north of the Sahara in Algeria, Libya, and Egypt reveal similar patterns of man-accelerated desert encroachment. Also, the fringe areas of the Rub al Khali, or Empty Quarter, of Saudi Arabia demonstrate the constant struggle by sparse vegetation against the ravages of nature confounded by the impact of man and animals.

This study is approached with an ecological perspective—emphasizing the resource base for livestock grazing and rainfed crop production. Periodic drought, such as the major one during the period 1968-1974 that caused political upheaval and widespread starvation of livestock and people, must be considered as a basic component of the environmental complex. This major drought focused the world's attention on this fragile environment. Since this drought, substantial amounts of food aid and development assistance have been sent to the area. The dual challenge for the area is to increase food production for a population that will double in about 25 years and, at the same time, to reverse the process of desert encroachment and resource deterioration.

For the purposes of the study, the ecological zones as defined by climatic factors are the Saharian (less than 200 mm of rainfall), the Sahelian (200-400 mm of rainfall), and the Sudanian (400-800 mm of rainfall). A discussion of climate, soils, vegetation, energy, demographic characteristics, infrastructure, agricultural practices, and regional political and development organizations are part of the main report. Also, the report deals with the causes of desert encroachment and some proposed solutions to this problem as the countries in the region struggle to produce food for an expanding population.

The Sahelian Zone in Chad, indicating typical heavy grazing around water holes.

At present, about 50 million people live in the Sahelian and Sudanian zones. While it may be possible to sustain this many people with proper management of the resources, it is also apparent that, under present practices, the soils and vegetation are rapidly deteriorating. The process of desertification is obvious, measurable by accepted scientific standards, and largely man-caused. "The problem is simply that there are more people and more animals on the land than it can support"—and, the population is expected to double in about 25 years.

Overall food production is not now keeping pace with population growth. To increase food productions and, at the same time, slow down or reverse the desertification process, will require the adoption of a "holistic approach." The following eight categories are considered essential to this "formula for progress":

1. Responsible government programs and policies.
2. Proper use of resources—land, water, vegetation, energy.
3. Education and research as an investment in progress.
4. Focus on the farmer and pastoralist to create the incentive to produce.
5. Application of science and appropriate technology.
6. Balanced family nutrition.
7. Effective development assistance.
8. A consideration of the ecological balance.

Adaptations of this formula must be made to fit individual country situations. Futhermore, without the cooperation and commitment of local people, governments, and institutions, no permanent progress can be made.

The Rockefeller Foundation has some unique capabilities to assist with the dual challenge in the area. However, in these regions of low rainfall and fragile environments, the possibilities for simple solutions and rapid payoffs are remote. Nevertheless, there are good opportunities for improving coordination and communications among development agencies, assisting with education and training programs, and stimulating new innovations in research, particularly on water conservation, energy alternatives, and proper land use. The magnitude of the challenge should not discourage an appropriate beginning.

Range reseeding has been successful only in areas fenced from nomadic grazing.

Cattle ready for slaughter in northern Nigeria.

Termites probably consume more biomass than livestock in the Shahelian/Sudanian part of Africa.

Dan W. McKenzie, *Chairman*

Activities

- The VREW 36th annual report on the February 4 and 5, 1982, Denver, Colo., meeting was prepared, and 3,000 copies were printed and distributed.

- The agenda for the 37th annual meeting, Albuquerque, N.Mex., February 13 and 14, 1983, was prepared for the meeting.

- *History of the Vegetative Rehabilitation and Equipment Workshop (VREW), 1946-1981*, was completed and distributed. Copies were available at the Albuquerque meeting. Additional copies may be obtained from the USDA Forest Service, Missoula Equipment Development Center, Bldg. 1, Fort Missoula, Missoula, MT 59801.

- The Chemical Plant Control Workgroup is working on an aerial herbicide application handbook. See Chemical Plant Control Workgroup report by Ray Dalen for more information.

- The San Dimas Equipment Development Center supported a training session and workshop designed to assist land managers in the selection of species, the use of equipment, and the employment of management practices to restore range and wildlife sites. The session was sponsored by the USDA Forest Service Intermountain Forest and Range Experiment Station and Region 4; and the USDI Bureau of Land Management. Over 400 attended the workshop, which took place at Elko, Nev., June 22-24, 1982.

- The San Dimas Equipment Development Center presented a paper entitled "Equipment for New Reclamation Challenges," at the Reclamation of Mined Lands in the Southwest Symposium held at Albuquerque, N.Mex., October 20-22, 1983. This symposium was sponsored by the Soil Conservation Society of American, USDA Forest Service Rocky Mountain Forest and Range Experment Station, and Western Agriculture Experiment Station's Coordinating Committee on Mine Waste Reclamation made up of members of USDA, State universities, and others.

- James A. Young, range scientist, USDA Agricultural Research Service, Reno, Nev., and Dan McKenzie, mechanical engineer, Equipment Development Center, Forest Service, San Dimas, Calif., published in *Rangelands* magazine an article describing the development and use of the rangeland drill, which is VREW's most successful project.

Projects

Two VREW-funded projects come under the Information and Publications Workgroup:

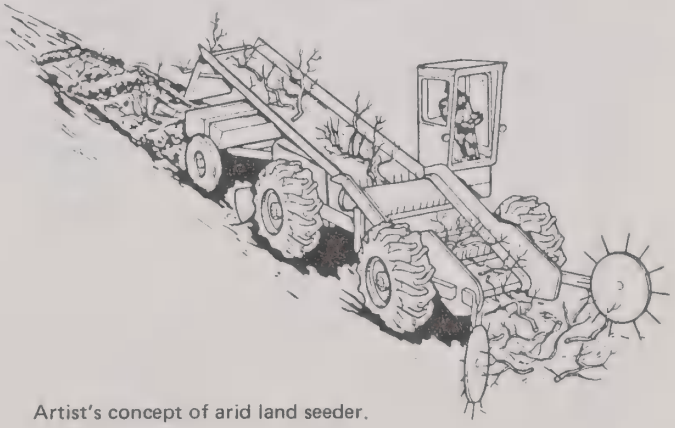
1. Range Habitat Improvement Video Tape (0E02D19).

2. Problem Area Investigation and Definition (1E11D42).

The range habitat improvement video tape entitled "Mechanical Range Improvements" has been completed. Copies have been made for each Forest Service Regional Office and for the BLM. Copies can be borrowed from the Forest Service by writing to USDA Forest Service, Equipment Development Center, Bldg. 1, Fort Missoula, Missoula, MT 59801. Copies may be purchased from the Missoula Center at a cost of about $35.

The goal of the Problem Area Investigation and Definition project is to prepare a separate prospectus, if further development is indicated, or prepare a report, if further development work is not indicated or desired, on each problem area suggested. A number of range equipment problem areas have been suggested and prioritized. Four prospectuses have been completed and two reports are in final preparation. Suggested range equipment problem areas, in order of priority and current status, are:

1. Arid Land Seeder: *Arid Land Seeder Development—A Prospectus* has been completed. The concept of an arid land seeder has been demonstrated to be valid and workable by treatment of 335 acres in southern New Mexico. A full-scale engineering development phase is now needed to complete the development and implement the use of the arid land seeder. The most important product of the full-scale engineering development effort would be a technical data package from which additional arid land seeders could be fabricated. The prospectus was prepared by SDEDC and Jornada Experimental Range, ARS, Las Cruces, N.Mex.



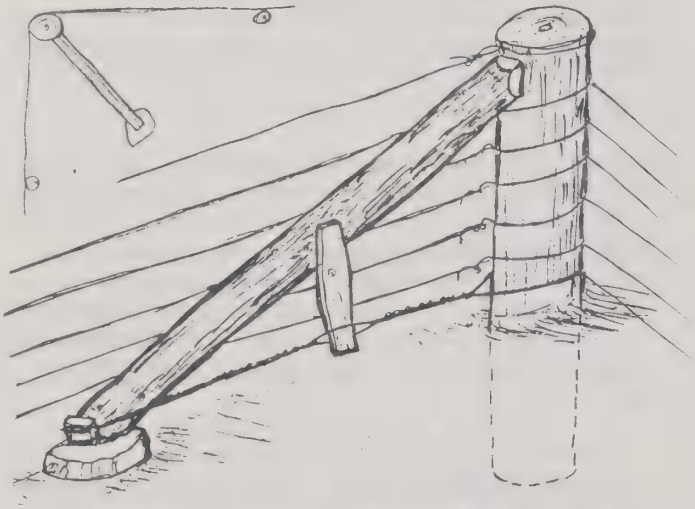
Artist's concept of arid land seeder.

2. Range Fencing Systems: A report, *Rangeland Fencing Systems State-of-the-Art Review,* is in final preparation. Conclusions from the review are:

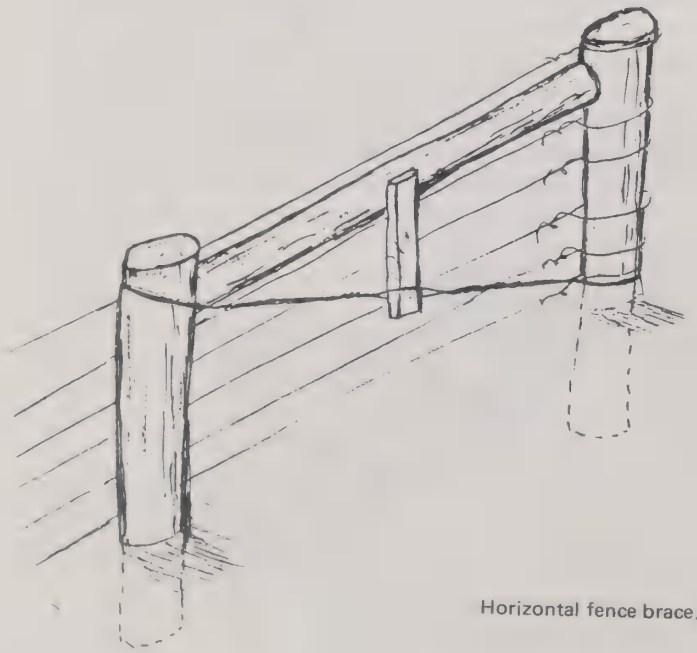
- Conventional rangeland fencing systems and practices have reached a state of development where new and innovative fencing systems are not expected to emerge that will result in substantial cost reduction of range fencing.

- Two types of fencing do offer some possibility of reducing fencing costs when used under proper circumstances. They are the New Zealand electric fencing systems, and high-tensile, smooth-wire fencing systems.

- Reduction in fencing costs could also be achieved by using the diagonal brace in place of the horizontal brace for corner, gate, or fence end braces.



Diagonal fence brace is structurally equal to the horizontal fence brace.



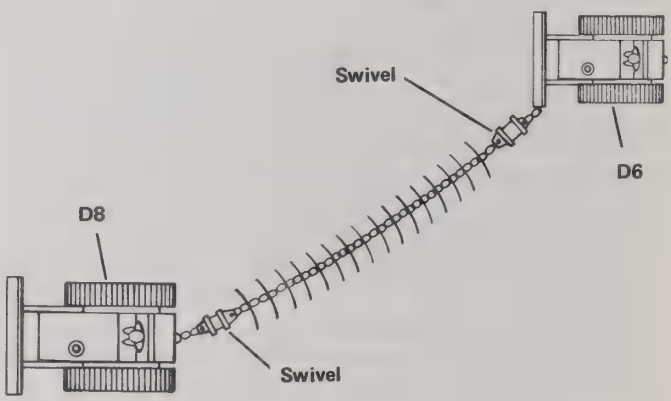
Horizontal fence brace.

- Many good local practices offering cost reductions are in use or are being developed that are not well documented.

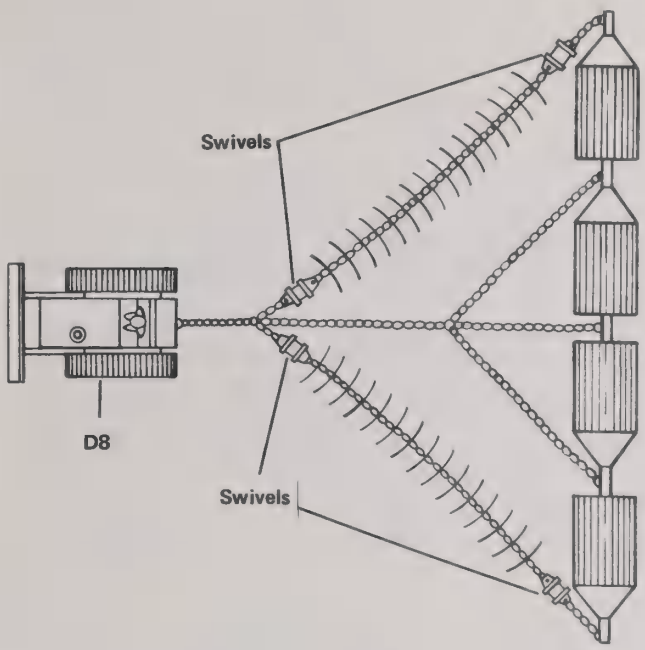
- Fencing considerations for wildlife or other special functions exist in literature but not in one, useful reference source.

- High-tensile, smooth-wire fencing may largely replace barbed-wire fencing, and the diagonal brace can replace the horizontal brace; for the diagonal brace is structurally equal to the horizontal brace. The reason for high tensile, smooth wire replacing barbed wire is the high tensile, smooth wire is slightly less expensive and causes less damage to livestock and humans. The reason for replacing the horizontal brace with the diagonal brace is the diagonal brace costs less. The diagonal brace requires only one post (less material) and less than half the labor to construct. The report, *Rangeland Fencing Systems State-of-the-Art Review,* is being prepared by Colorado State University, Fort Collins, Colo., and SDEDC.

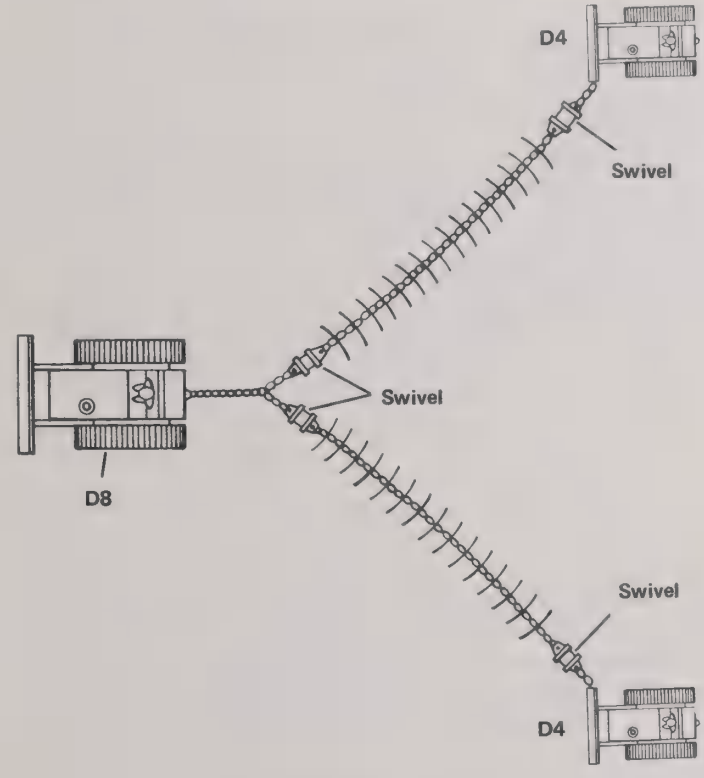
3. Disk-Chain Implement: *Development of a Disk-Chain Implement for Seedbed Preparation on Rangeland—A Prospectus* has been completed. The Texas Agricultural Experiment Station of Texas A&M University, Vernon, Tex., demonstration model disk-chain has validated, by the treatment of almost 2,000 acres, the improved grass-stand establishment effectiveness over smooth chaining with a predicted cost reduction of seedbed preparation of ½ to ¾ when compared to seedbed preparation by use of standard disking equipment. To complete the development of the disk-chain, a full-scale engineering development effort must be completed in which the optimum blade size, chain size, and pulling method are determined for different soils, soil depths, and vegetation; followed by the design, fabrication, and field-pulling performance testing of a full-size disk-chain. Three methods of pulling the disk-chain are proposed—one-, two-, and three-tractor arrangements (see figures). The prospectus was prepared by the Texas A&M University, Agricultural Research and Extension Center and SDEDC.



Two-tractor pulling technique for a disk-chain implement.



Single-tractor pulling technique for a disk-chain implement.



Three-tractor pulling technique for a disk-chain implement.

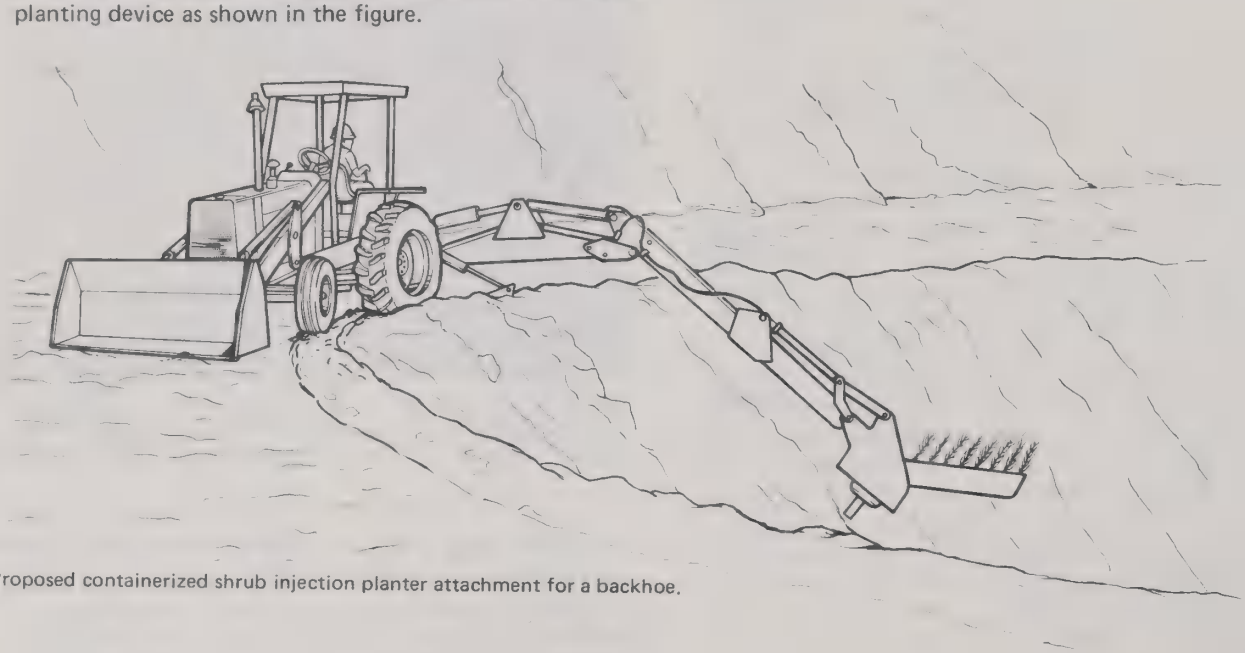
4. Punch Seeder: *Punch Seeder for Arid and Semiarid Rangelands—A Prospectus* has been completed. The concept of punch seeding has been shown by research experiments to have merit. This seeding technique now needs to be demonstrated and validated in the field. A self-propelled, rubber-tired, intermittent, dibble-type container transplanter, now under development by the Agricultural Engineering Department at the University of Idaho, could be used to demonstrate and validate punch seeding. If, after evaluation of seedings, the results indicated the desirability of punch seeding, full-scale engineering development of a punch seeder can begin by the design and fabrication of a production prototype. The punch seeder prospectus was prepared by the University of Idaho, Moscow, Idaho, and SDEDC.

Self-propelled punch seeder/steep slope planter under development by the Agricultural Engineering Department, University of Idaho. This unit could be modified to demonstrate and validate punch seeding.

5. Mulch Spreading Equipment: A state-of-the-art review on mulch spreading equipment for steep slope revegetation and mine reclamation is being prepared. The objectives of the investigation were to review the currently available mulch spreading equipment and determine the need for research and development of mulch handling and spreading equipment by Government agencies and research institutions. The investigation showed development of new mulching equipment for mineland reclamation and steep slope revegetation to be unnecessary by Government agencies. The requirements for mulch spreading equipment recommended by industry experts and researchers are largely met by available equipment, and manufacturers are actively improving existing designs to fully meet requirements. The report on mulch spreading equipment is being prepared by Colorado State University, Fort Collins, Colo., and SDEDC.

6. Backhoe Containerized Shrub Injection Planter Attachment: *Development of a Containerized Shrub Injection Planter Attachment for a Backhoe—A Prospectus* was completed. A containerized shrub injection planter attachment is proposed for use with a standard backhoe in place of the backhoe bucket. This attachment will speed planting rates, reduce damage to the slopes by hand-planters, reduce labor needs, and reduce costs. The USDA Forest Service Intermountain Forest and Range Experiment Station at Boise, Idaho, estimates that by using a 35-foot-long boom, between 65 and 75 percent of the cuts and fills in the Idaho Batholith could be planted mechanically.

The concept of mechanically punch-planting road cuts and fills on the Idaho Batholith was shown to have merit through simulation studies. What is needed now is to demonstrate and validate this planting procedure in the field. Steep-slope punch-planting with a backhoe can be demonstrated and validated by designing, fabricating, and testing a demonstration planting device as shown in the figure.



Proposed containerized shrub injection planter attachment for a backhoe.

The prospectus was prepared by the University of Idaho, Moscow, Idaho, and SDEDC.

Work has not yet started on the following:

7. Reclamation of mine spoil by vertical mulching.
8. Investigation of self-leveling tractors.
9. Mineland trencher.
10. Mulch gathering equipment.
11. Bandoleer grass transplanter.
12. Backpack seed collector.

Plans

1. Prepare, publish, and distribute VREW 37th annual report.
2. Prepare and distribute, 45 days in advance of meeting, agenda for 38th annual meeting, which will be in Rapid City, S.Dak., February 12 and 13, 1984.
3. Complete these two reports: *Rangeland Fencing Systems—State-of-the-Art Review; Mulch Spreading Equipment for Steep Slope Revegetation and Mine Reclamation—A State-of-the-Art Review.*

Bill McGinnies, *Chairman*

Vertical-Axis Tiller

Field tests of the vertical-axis tiller continued in 1982. The model tested was the Lely RH200-20, which has a working width of 80 inches (2 meters) and is designed for tractors of 40 to 75 pto horsepower.

On a saltgrass meadow in northcentral Colorado, the tiller was effective if the sod was first loosened with a chisel plow. The vertical-axis tiller does not turn the soil over as much as conventional rotary tillers or as much as plowing. Because of this, weed seeds are not buried by the vertical-axis tiller and weed densities were much higher than for the other two methods of seedbed preparation. However, seeded stands of Russian wildrye were generally better with the vertical-axis treatment.

In mulching studies in northcentral and northwest Colorado, the vertical-axis tiller could effectively incorporate 1,000 pounds per acre of either straw or grass-hay mulch with one pass over the area. With 3,000 pounds of mulch per acre, two passes were required. It was also found that the front of the tiller must be raised or the tiller will push mulch ahead rather than incorporate it.

The seedbed produced by the vertical-axis tiller is not as loose as that prepared by conventional rotary tillers. In spite of this, areas treated with the vertical-axis tiller should probably be cultipacked at least once. The combination of vertical-axis tillage and cultipacking has produced excellent smooth, firm seedbeds on soils that varied from sandy to clayey.

On several occasions, the vertical-axis tiller was used to prepare seedbeds when the soil was too wet to be worked with the usual plow and disk procedures. The tiller produced a satisfactory seedbed under these conditions in spite of a moderately high clay content of the soil. On hard, dry soils, tilling is much more efficient if the soils are first loosened with a ripper or chisel.

The only operational problem encountered with the Lely tiller is the sharp angles of the pto U-joints that result from the input shaft of the tiller being much higher than the tractor's pto shaft. The sharpness of these angles is accentuated when the front of the tiller is raised to incorporate mulch. The operator should always disengage the pto before raising the implement with the hydraulic lift, or damage to the U-joints can result.

In 1982, a "Lelymatic Shearpin Automat" automatic shearpin replacer was installed on the tiller. This device contains 10 shearpins in spring-loaded holders and each shearpin can be broken 4 times; this allows for 40 shearpin breakages before it is necessary to reload the device with new shearpins. In one test on a rocky soil in northwest Colorado, approximately 20 shearpin breakages occurred in less than 1 hour. If it had been necessary to manually replace shearpins, it would have required more than an hour to do this alone. The shearpin replacer was reliable in all respects; shearpins consistently broke when heavy obstructions were encountered, but no shearpins broke unless there was an obstruction.

To replace a shearpin with the automatic shearpin replacer, the operator stops the forward motion of the tractor and disengages the pto. As the pto slows and stops, a new shearpin automatically is pushed into place. The operator then lifts the tiller to clear the obstruction, lowers the tiller back into operating position, reengages the pto, and resumes his forward travel. The Leymatic automatic shearpin replacer is currently available only for the Lely tiller. However, the replacer is a self-contained unit that could readily be adapted to other equipment, and Lely will probably make these available for other applications in the future.

No further testing of the vertical-axis tiller is planned for 1983.

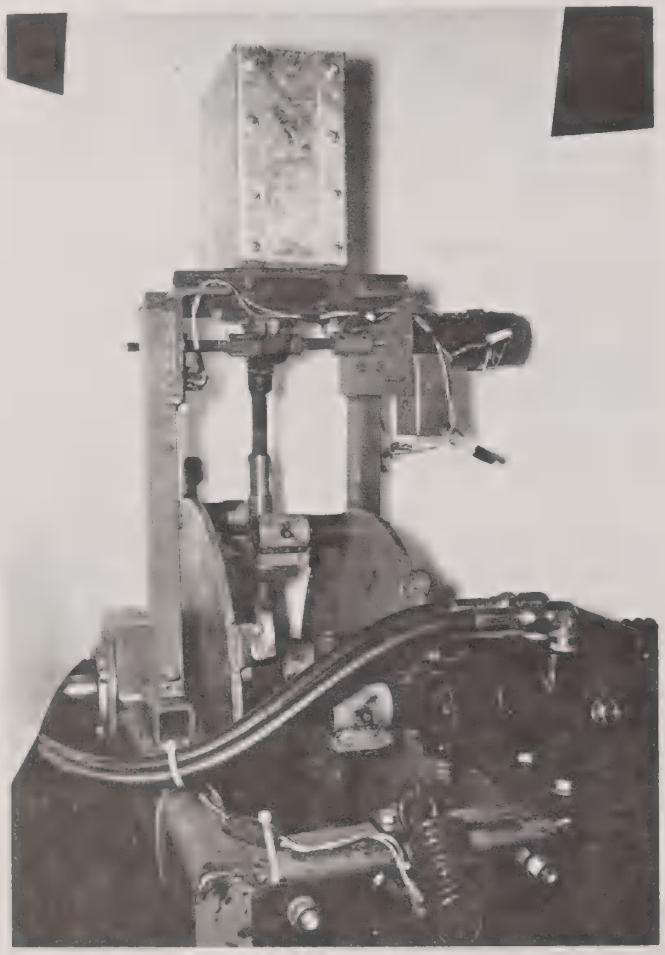
Punch Seeding Using the University of Idaho Steep Slope Planter

By Walter L. Moden, Jr., University of Idaho, Moscow, Idaho

In late November of 1982, approximately one-fourth of an acre of steep grazing land was interseeded with bitterbrush using the punch seeding method employing the University of Idaho steep slope planter. The planting site was on Idaho Fish and Game Department land, located northeast of Boise, Idaho. Because this area is an important wintering area for deer and is now largely vegetated with grass, an attempt is being made by the Idaho Fish and Game Department to establish suitable browse for winter deer feeding.

University of Idaho planter punch seeding bitterbrush southeast of Boise, November 1982.

An electrically driven seed metering device was mounted on the dibble type planter that was developed to transplant grass seedlings by the Agriculture Engineering Department at the University of Idaho and the USDA-ARS, Grassland, Soil, and Water Research Laboratory, Temple, Tex. Six to eight bitterbrush seeds were metered into each dibble. The dibbles entered the soil vertically to a depth of 1.5 inches or less. As the dibbles start to leave the soil, a trap door in the dibble opens to release the seeds. The planting hole was not covered or sealed. Normal sloughing of soil was allowed to cover the seeds. The planting site was on a southerly exposure having a 10 to 30 percent slope. Hole spacing was 1 foot apart within the row. Very little if any surface soil disturbance could be detected after planting. The hole size is 1 inch in diameter.



Seed metering and punch dibble on University of Idaho planter.

A seed germination count was made on March 31, 1983. A 9 percent germination rate was counted. Since the counts were made early in the germination period, additional plants should continue to emerge. A 9 percent germination is very acceptable for this type of planting. A 7 percent germination is considered to be successful when direct seeding using a drill. The seed holes were still open when the germination counts were taken. This method of seeding may prove to be very advantageous when planting areas where keeping surface soil disturbance to a minimum is desired.

Bandoleer Grass Transplanter—Progress Report

By Victor L. Hauser, Agricultural Research Service, Temple, Tex.

During calendar year 1982, extra funds from the budget of USDA-Agricultural Research Service were made available to continue work on the bandoleer grass transplanter at Temple, Tex. The electronic feed and cutoff mechanism could not be successfully operated nor was it possible to modify it so it would be operable. The major problem was the bandoleer strips changed dimensions as they moved through the feed rolls. The changes were dependent on the moisture content of the plugs in the bandoleer, stage of root growth, and other unknown factors. The electronic feed system was discarded in favor of a fluted roller mechanical system that seems to work much better. Also, the planting accuracy of the dibbles was improved by adding 10 to 20 percent No. 3 sand to the bandoleer plug mix. The sand increased the weight substantially with only a small loss of water-holding capacity. Plans are to extensively field test the new mechanical feed system in the spring and summer of 1983.

Gel Seeding Woody Plants—Progress Report

By D. Terrance Booth, Agricultural Research Service, Cheyenne, Wyo.

Research is being done at the USDA-ARS High Plains Grasslands Research Station, Cheyenne, Wyo., to evaluate several aspects of gel seeding woody plant species. Seed dormancy and low seedling vigor are the primary reasons the establishment of cultures of woody plants has largely depended on intensive, high-cost methods. Gel seeding technology has the potential of reducing this cost. It is suggested that gel seeding will be a method of planting fully imbibed, easily damaged seed that has been treated in the laboratory to overcome dormancy. Preliminary data from current studies indicate that treated seed can be stored at low temperatures and moist conditions until field situations favor successful planting establishment. Gel seeding also offers a means of dispensing fluffy propagules, such as those of winterfat.

Mulch Spreading Equipment for Steep Slope Revegetation and Mine Reclamation

By Carol S. Taylor, Colorado State University, Fort Collins, Colo.

Following is a brief summary of a state-of-the-art review report on mulch spreading equipment for steep slope revegetation and mine reclamation that is being completed by Colorado State University and the Forest Service Equipment Development Center, San Dimas, Calif.

To better evaluate the different types of mulch spreaders, they were divided into several categories, and criteria for evaluating the equipment in each category was developed. Criteria were developed from equipment user input, literature review, and researchers' recommendations. For each category, the criteria were used to evaluate the equipment and rank equipment based on satisfying the criteria.

Equipment used for spreading and incorporating mulch were placed into the following four categories:

- Mulch spreaders.
- Power mulchers.
- Hydraulic mulcher-seeders.
- Mechanical mulch incorporators.

Mulch Spreaders

Mulch spreaders distribute mulch directly onto the land through a variety of spreading techniques. The following criteria were developed to evaluate mulch spreaders:

1. Distribute fiber mulch without reducing fiber length.
2. Designed to withstand rough terrain.
3. Capable of distributing several mulch materials.
4. Have a low labor requirement.
5. Apply mulch quickly and efficiently.

Of the mulch spreaders that were evaluated, several units met most of the criteria for the ideal mulch spreader. The All-Round Feeder mulch spreader, a modified farm tub grinder developed by the Marcy Equipment Co. of Greeley, Colo., met all the established criteria. The combination of features that distinguishes this unit from other mulch spreaders includes a high distribution rate, self-loading capability, and distribution of fiber mulch without reducing fiber length. The Mulch Master and Big Bale Buster are also outstanding mulch spreaders; both are distributed by Lo-Co Equipment Co.

All-Round Feeder Mulch Spreader self-loading round bales.

All-Round Feeder Mulch Spreader in operation.

Power Mulchers
Power mulchers are designed to spread mulch at greater distances than mulch spreaders and are especially well adapted to mulching steep slopes and inaccessible areas.

Criteria for power mulchers:

- Distribute mulch quickly and efficiently.
- Distribute mulch at great distances.
- Maneuverable in rough terrain.

Power mulchers are manufactured by Finn, Bowie, and Reinco. Models manufactured are similar in design, cost of operation, and labor requirement, and were evaluated together. Overall, Finn, Bowie, and Reinco power mulchers are good mulch distributers and met most of the criteria for the ideal equipment types.

The Estes Spreader is a power mulcher that differs in design from the Finn, Bowie, and Reinco models. This unit consists of a truck- or trailer-mounted hopper with a blower/spreader for mulch distribution. The Estes Spreader also met most of the established criteria for the ideal power mulcher but is unsuitable for rough terrain.

Power mulcher in operation.

Hydraulic Mulch-Seeders
Hydraulic mulcher-seeders apply mixtures of seed, fertilizer, mulch, and tackifier in a water-based slurry. Hydraulic mulcher-seeders are capable of covering large areas and are effective for mulching and seeding steep slopes.

The ideal hydraulic mulcher-seeder should be capable of slurry agitation without seed-coat damage and optimally should use the least amount of water per load of mulch. There are few differences between the commercially available hydraulic mulcher-seeders produced by Bowie, Finn, Erocon, and Reinco. Generally, all these machines do a good job of applying mulch and seed. Hydraulic mulcher-seeders manufactured by Bowie appear to have a slight advantage over other models in that seed damage is reduced through an agitation system that does not recirculate the slurry. Recent research conducted by Bowie indicates its hydraulic mulchers can distribute equivalent amounts of mulch with substantially less water.

Hydraulic mulcher-seeder in operation.

Mechanical Mulch Incorporators

This category of mulch spreader includes equipment that ranges from specially designed crimpers to weighted agricultural disks, roller, and other farm implements. Optimally, mulch incorporators should:

- Thoroughly integrate mulch with the soil.
- Work well in rocky soils without equipment damage.
- Have adjustable tiller depth.
- Produce a smooth seed bed.

The Lely vertical-axis tiller was considered the ideal implement for stabilizing loose fiber mulch. Special features that distinguish this unit include a stonebar for burying loose rock and a roller that breaks up large clods, leaving a smooth seedbed. The AAREC crimper is also a superior model with flexible, three-part gangs that allow passage over rocks without equipment damage.

Another piece of equipment that was included in the review (because this machine is unique in design, operation, and capability), but is not strictly a mulch spreader or incorporator, is the Madge Rotoclear. The function of the Madge Rotoclear is to clear areas of small trees, stumps, and brush and break or cut up the material. The plant material is passed through a rotor consisting of many self-sharpening teeth and incorporated into the soil. Advantages of using the Madge Rotoclear include incorporation of woody material into the topsoil where it acts like a mulch and promotion of volunteer suckering. The machine saves time and money by clearing and mulching in one operation.

AAREC mechanical mulch incorporator.

Madge Rotoclear.

Arid Land Seeding

Harold T. Wiedemann, *Chairman*

The Arid Land Seeding Workgroup reports activities under the following format:

I. Extensive area seedings

A. Improved grasses

B. Seedbed preparation

C. Seeders

1. Ground

2. Aerial

D. Grass seed modification

II. Critical area seedings.

Abstracts of individual reports are included. During this past year, three prospectuses were prepared recommending expanded activity and the necessary funding to accomplish goals. Titles were:

- *Development of a Disk-Chain Implement for Seedbed Preparation on Rangeland*
- *Arid Land Seeder Development*
- *Punch Seeder for Arid and Semiarid Rangelands.*

Copies are available on request from the San Dimas Center.

Triangular Disk-Chain for Rangeland Seedbed Preparation

By Harold T. Wiedemann, Texas Agricultural Experiment Station, Vernon, Tex.

A new triangular disk-chain, requiring only one tractor for pulling, developed by the Texas Agricultural Experiment Station, has reduced pulling requirements by 30 percent and increased operating width by 22 percent, compared to the standard two-tractor, diagonal pulling techniques.

Two disk-chains are positioned to the rear and on both sides of the pulling tractor and then a large roller, attached to the outer end of both chains, holds them apart at the proper angle. The roller may also be of assistance in preparing a better seedbed. A microprocessor-controlled load cell recorded pulls of 150, 178, and 236 lb/blade for 24-, 28-, and 30-inch-diameter disk blades, respectively. Disk-chained seedbeds have increased seeded grass densities by 92 percent in clay loam soil aerially seeded with 1 or 2 pounds of pure live seed per acre of kleingrass compared to seedbeds prepared by smooth chaining on rootplowed rangeland. Another advantage of the triangular disk-chain, besides using only one tractor and operator, is the lack of side draft on the pulling tractor. This results in reduced wear of the crawler tractor's tracks and track rollers. For further information on this implement, contact Harold Wiedemann, Texas Agricultural Experiment Station, P.O. Box 1653, Vernon, TX 76384, (817) 552-9941.

Newly developed triangular disk-chain holds promise for improved, cost-effective rangeland seedbed preparation. This disk-chain requires only one tractor to pull it and has a 20-foot swath.

Land Imprinting Activities

By Robert M. Dixon, Agricultural Research Service, Tucson, Ariz.

Land imprinting and desertification control research were accelerated in 1982 because of increased support. A new device called the brush-barrel seeder was developed and successfully used with the land imprinter to impose treatments at the University of Arizona's Page Range and in Avra Valley on the Agua Blanca Ranch and Rucson's municipal well-field land, which has only recently been retired from irrigated cotton.

The brush-barrel seeder features a nylon street cleaning brush enclosed in a cylindrical seed hopper of slightly larger diameter. The brush serves to continuously mix the seed in the hopper while sweeping some seed through discharge ports. It is driven by a large plyboard gear with steel faced teeth enmeshing the imprinting teeth. Like the modified electric broadcast seeders used with land imprinters, the new seeder has but one moving part. Brush, rocks, and moist soil lodging in the imprinting teeth interfere very little with seeder operation because the seeder mount is hinged and springloaded allowing the entire assembly to swing away from the imprinter when an obstruction is encountered.

Brush-barrel seeder for disseminating trashy heterogeneous seed mixes.

New experimental sites were selected to represent various stages of desertification resulting from prolonged overgrazing and overcropping, including the general vegetative types: mesquite, creosotebush, cactus, tumbleweed, and barren or denuded. Revegetation treatments included: (1) ripped, seeded and imprinted; (2) seeded and imprinted; (3) hand-seeded; (4) drill-seeded; and (5) untreated. Treatments were laid out with long contiguous borders to facilitate paired comparison analyses. The Page Ranch and Avra Valley locations were treated in May and November, 1982, respectively.

Treatment response at Page Ranch from normal summer rainfall was typically rapid with the grass in the imprinting treatment forming seed heads at a one-half meter height just 6 weeks after seedling emergence. Stand density and forage production under the imprinting treatment was superior to the drill treatment. Compared with drill furrows, imprints were observed to stay wet several days longer after summer rains and several weeks longer after winter rains. Some processes apparently underlying the prolonged wetness of imprints include: (1) concentration of rainwater in the bottom of imprints; (2) deep infiltration of the concentrated rainwater; (3) suppression of transpiration and evaporation through crushing and mulching of top growth; and (4) compression of imprint bottoms to enhance upward capillary flow into the seedbed as the soil surface drys.

Other activities included the testing of different sized right-angled conical and pyramidal imprinting teeth under both simulated and natural rainfall in an effort to improve seedbeds and seedling cradles. Duration of capillary moisture flow to the imprinted seedbeds increased with the basal or surface collection area of the imprint. Aluminum foil imprint liners were tested as a means of making wetter seedbeds and seedling cradles through imprint stabilization and evaporation suppression. Preliminary results were consistent with expectations.

Home-fabricated imprinters were used by ranchers to revegetate overgrazed rangeland on the Falcon Valley Ranch, Oracle, Ariz., and the Broken Arrow Ranch, Gunnison, Utah. Don Larson, owner of the Broken Arrow Ranch, fabricated his imprinter from blacktop highway rollers as did Gerald Hall of Levin, Utah, a year earlier. The Tonto National Forest imprinted several severely overgrazed test sites near Payson and Young, Ariz., in both spring and fall of the 1982 growing season.

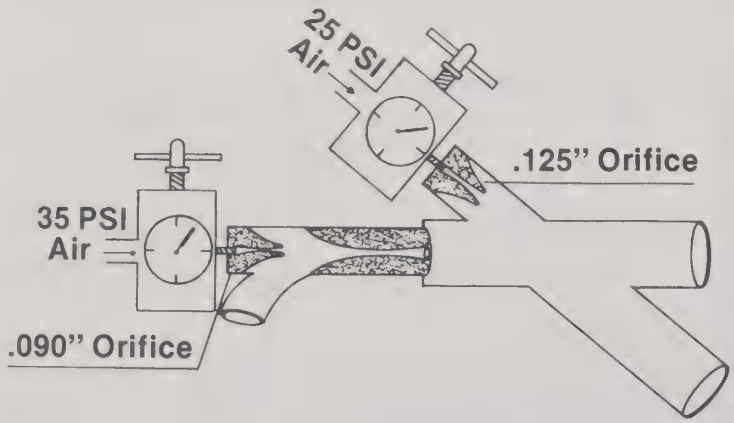
Future work will be directed at evaluating environmental effects of imprinting revegetation systems and to improving imprinting teeth and their patterns to better accomplish revegetation and interseeding objectives.

Border contrasting seeded-imprinted treatment (left) with hand treatment.

Modification of Chaffy Seeded Grasses With Air

By C.L. Dewald, Agricultural Research Service, Woodward, Okla.; V.A. Beisel, Aarons Engineering, Fargo, Okla.

Aerodynamic methods to modify chaffy grass seed by removal of awns, hairs, fuzz, and chaff shows promise in early trials. The air compressor-driven power unit uses a venturi-shaped nozzle to propel air through a mixing chamber and into a venturi-shaped discharge muzzle. As the pressure decreases, due to increased velocity in the venturi constriction, the resulting vacuum formed in the mixing chamber pulls air entrained seed into the power unit. Seed is expelled from the venturi muzzle at supersonic speeds capable of detaching part or all of the chaff from the seed. Separation of the chaff from the seed is accomplished with a Y-shaped air classifier attached to the power unit muzzle. The air and chaff exits through the opening opposite the classifier air nozzle and momentum of the heavier seed propels them forward against a slight vacuum through the second opening in the Y, thus achieving separation.



Y-shaped air seed classifier.

Wendall Oaks, *Chairman*

The Plant Materials Workgroup objectives include:

1. Identification and recommendation of needed research on species, techniques, and equipment for reseeding, harvesting, and processing plant materials.
2. Dissemination of new information on adapted species, production and establishment techniques, and processing plant materials.
3. Stimulation of interaction between and among private, local, State, and Federal groups concerned with development, production, and use of new plant materials and techniques for their application.

Examples of projects and/or activities include:

1. Developing a listing of cultivars for reclamation.
2. Developing a slide set and narrative of new cultivars for range, pasture, and critical area stabilization, etc.
3. Maintaining a national source list of plant materials and cultivars for use in critical area stabilization, rangeland, etc.

Sources of Seed and Planting Stock pamphlet remains current and will not be revised until spring 1984. Copies remain available from: USDA Forest Service, Equipment Development Center, Bldg. 1, Fort Missoula, Missoula, MT 59801.

Newly Released Plant Materials

Scientific name	Cultivar	Common name	PI or other No.	Source	Date released	Agency Participation		PMC
						Primary	*Others*	
Atriplex canescens	Rincon	fourwing saltbush	U103P	NM	1982	SCS	Colorado & Utah AES, Forest Ser.	Meeker
Cynodon dactylon	Brazos	bermudagrass	464656		1982	TX A&M	SCS	Knox City
Crotalaria juncea	Tropic Sun	sun hemp	468956	HA	1982	SCS	HAAES	Hawaii
Salix cottelii	Bankers	willow	434285	MD	1983	SCS	US Forest Service	Quicksand
Castanea pumila	Golden	chinquapin	421739	GA	1983	SCS	Dept. of Natural Resources	Quicksand
Agropyron smithii	Rodan	western wheatgrass			1982	SCS		Bismarck
Bouteloua curtipendula	Haskell	sideoats grama	433946	TX	1983	SCS	TAES	Knox City
Desmanthus illinoensis	Sabine	Illinois bundleflower	434011	TX	1983	SCS	TAES	Knox City
Celtis occidentalis	Oahe	hackberry	T-5725	SD	1982	SCS	ARS	Bismarck
Cornus amomum	Indigo	silky dogwood	468117	MI	1982	SCS	MI Dept. of Natural Resources	Rose Lake
Sporobolus airoides	Salado	alkali sacaton	434444	NM	1983	SCS	NMSU, CSU	Los Lunas
Rhus trilobata	Autumn Amber	skunkbush sumac	T9467	TX	1982	SCS	NMSU	Los Lunas
Bouteloua curtipendula	Niner	sideoats	T4495	NM	1983	SCS	NMSU, CSU	Los Lunas
Chilopsis linearis	Hope	desertwillow	T04522	NM	1982	NMSU	SCS	Los Lunas
Bothriocloa ischaemum	WW Spar	old world bluestem	301573	SW Asia	1982	ARS	OKSU	
Agropyron cristatum	Emphraim	crested wheatgrass		Turkey	1983	SCS	USFS, ID & UT AES	Aberdeen
Dactylis glomerata	Paiute	orchardgrass		Turkey	1983	SCS	USFS, ID & UT AES	Aberdeen
Andropogon gerardi	Roundtree	big bluestem			1983	SCS	USFS, AZ, ID & UT AES	Elsberry
Sorghastrum nutans	Rumsey	indiangrass			1983	SCS	US Forest Service	Elsberry

One publication of interest was completed this year:

Reclamation of Mined Lands in the Southwest—A Symposium, October 20-22, 1982. A list of newly available plant materials is included in this report.

Plant Materials Workgroup representatives gave five reports at the VREW meeting:

- Seed Coating "Hard to Drill" Seeds, Wendall Oaks, Soil Conservation Service.
- Plant Materials Progress in Texas, Richard Heizer, Soil Conservation Service.
- Colorado Environmental Plant Center, Sam Stranathan, Soil Conservation Service.
- Old World Bluestem Release, Dr. William Berg, Agricultural Research Service.
- Recent Releases in the Intermountain West, Richard Stevens, Utah Division of Wildlife Resources.

Seed Coating "Hard to Drill" Seeds

By Wendall R. Oaks, Soil Conservation Service, Los Lunas, N.Mex.

Most fluffy or trashy seeds are difficult to plant accurately. This is due principally to physical characteristcs such as shape, size, and seed appendages. Many range seedings may have failed as a result of poor seed dispersal. Often these failures have been falsely blamed on poor weather conditions.

The objective of the project activities at the USDA Soil Conservation Service Los Lunas Plant Materials Center (PMC) is to reevaluate the feasibility of coating trashy seed. Previous work was done in the 1950's when seed costs were very low. When seed cost 50 cents per pound, seed coating cost was uneconomical. Today, when the cost of some seed is $30 per pound (galleta), a 50-cent-per-pound coating cost is minimal. Economics is only one factor that might support recommending seed coating. Other advantages include:

- More accurate seed placement.
- Better seed mixing.
- Use of conventional equipment.
- Inclusion of nutrients, fungicides, or herbicides in the coatings.
- Reduced seeding rates.

Preliminary work continues on this project with additional seeds being coated and field studies planned for 1983. Initial germination tests show no detrimental effects from coating.

Plant Materials Progress in Texas

By Richard B. Heizer, Soil Conservation Service, Temple, Tex.

Since 1978 some eight new plant materials have been released and two are in review from Texas by the Knox City Plant Materials Center, Knox City, Tex., in cooperation with the Texas Agricultural Experiment Station and various other State and Federal agencies. Included are:

Alamo switchgrass
(*Panicum virgatum*)

Shoreline common reedgrass
(*Phragmites communis*)

T-587 old world bluestem
(*Dichanthium* spp.)

Yellow Puff littleleaf leadtree
(*Leucaena retusa*)

Aztec maximilian sunflower
(*Helianthus maximilliani*)

Loneta indiangrass
(*Sorghastrum nutans*)

Rainbow wild plum
(*Prunus* spp.)

Saltalk alkali sacaton
(*Sporobolus airoides*)

Plant materials to be released spring 1983:

Haskell sideoats grama
(*Bouteloua curtipendula*)

Sabine Illinois bundleflower
(*Desmanthus illinoensis*)

Also, the Texas SCS cooperated in four additional releases principally by ARS and/or Texas AES during this same period. These releases are:

Nueces buffelgrass
(*Cenchrus ciliaris*)

Verde kleingrass
(*Panicum coloratum*)

Llano buffelgrass
(*Cehchrus ciliaris*)

Brazos bermudagrass
(*Cynodon dactylon*)

Colorado Environmental Plant Center

By Sam Stranathan, Soil Conservation Service, Meeker, Colo.

The Upper Colorado Environmental Plant Center's first plant release is a cooperative one and a good one. Following in the spirit the Meeker Center was established 7 years ago, cooperation has spelled success for those associated with the Center and the Region's plant materials program.

The newly released Rincon fourwing saltbush is a product of collection and selection efforts by the Forest Service Shrub Science Lab (Provo, Utah), and field trials and orchard efforts by Utah Division of Wildlife Resources, Soil Conservation Service, and Meeker Plant Center.

Utilizing techniques developed over the last 25 years by Perry Plummer and culminated by Dr. Durant McArthur, the Meeker Plant Center has 3 acres of Rincon that further evaluates the creditability of the Forest Service technology. Plus the Meeker, Colo., environment tests the cold tolerances of Rincon.

Rincon is special, not only as a high quality performer, but has stable sexual characteristics that enhance intensified seed production. Plants that can be sexed permit orchard configurations that contain 80 percent female (seed producing) plants to 20 percent strategically placed male (pollen producing) plants.

Information from our seed cleaning facility confirms that Rincon seed production can be doubled where male-female ratios are controlled.

Sexed plants will be provided to private commercial orchards from the Meeker Plant Center. Seed produced and available for plantings from these private sources will be classed as certified Rincon. Rincon will be planted in Utah, Idaho, and Colorado in 1983. Requests are being taken for 1984 plantings.

The Meeker Plant Center provides foundation and registered seed to growers for 9 other popular plant materials. Over 25 acres of the 189-acre Center is in seed production.

New products in advance testing are (1) Utah sweetvetch, (2) Louisiana sagewort, (3) Slender wheatgrass, (4) Antelope bitterbrush, and (5) Serviceberry. Thanks to a lot of people, the Meeker Plant Center is contributing to the plant material needs of the Upper Colorado Region.

Old World Bluestem Release

By Dr. William A. Berg and C.L. Dewald, Agricultural Research Service, Woodward, Okla.

Old World bluestems (*Bothriocloa* spp.) from southwest Asia have high forage and beef production potential when seeded and managed as monocultures on the Southern Plains. These introduced bluestems also offer potential for warm season pastures on the hilly lands of the Southeast where tall fescue pastures are used during the cooler season. WW Spar bluestem (*Bothriocloa ischaemum*), a new release from the Southern Plains Range Research Station, has high forage production potential under less than optimum soil moisture conditions and is more palatable than many other old world bluestem selections. WW Spar has shown excellent persistence and spring vigor in test plots in Oklahoma, northern Texas, central Kansas, and southern Illinois. WW Spar like Caucasian bluestem, is susceptible to iron deficiency when grown on soils that are calcareous to the surface. Seed of WW Spar bluestem is available through the Oklahoma Foundation Seed Stocks, Inc.

Recent Releases in the Intermountain West

By Richard Stevens, Utah Division of Wildlife Resources, Ephraim, Utah

The Utah Division of Wildlife has been involved with revegetation work for many years. Many years of field testing recently culminated in the cooperative release of three new plants: Rincon fourwing saltbush, Ephraim crested wheatgrass, and Paiute orchardgrass. The following is a discussion of these releases.

Rincon Fourwing Saltbush

The Agricultural Experiment Stations of Colorado State University and Utah State University, the Utah State Division of Wildlife Resources, USDA Forest Service Intermountain Forest and Range Experiment Station, Soil Conservation Service, and the Upper Colorado Environmental Plant Center released Rincon fourwing saltbush (*Atriplex canescens* (Pursh) Nutt.) for commercial production and marketing of seed and plants.

Rincon originated from a seed collected near Canjilon, Rio Arriba County, N.Mex., at 7,800 feet elevation.

Rincon fourwing saltbush is a facultative evergreen shrub valuable for arid rangeland restoration. It is widely adapted, palatable, large in size, has good nutritive value, high rate of growth, and produces a large volume of foliage. Its leaves, stems, and utricles provide browse in all seasons for livestock and wildlife. In addition to providing forage and cover, Rincon is valuable for rehabilitation of depleted rangelands and for soil stabilization projects. It has potential for extensive use in mineland reclamation on arid and semiarid land of the Intermountain region. Its globular, leafy growth form make Rincon an outstanding conservation plant for soil stability and forage production. Rincon may be propagated easily by direct seeding, by transplants, and by stem cuttings.

Rincon fourwing saltbush is well adapted to a wide range of soil textures from sandy areas and gravelly washes to loamy soils. Moreover, vigorous plants occur also on heavy clay soils and on moderately saline soils. Rincon fourwing saltbush is best adapted to big sagebrush and pinyon-juniper zones, but it also does well in the more mesic portions of salt desert shrub areas. It appears to have salt tolerance similar to other fourwing saltbush ecotypes. Because of its high elevation origin, Rincon has shown adaptation in more northern

climates than might be expected. It has performed well at 3,000 to 8,000 feet elevation and with average annual precipitation of 9 to 23 inches.

Parent plants will be maintained by the Intermountain Forest and Range Experiment Station, Utah State Division of Wildlife Resources, and the Aberdeen, Idaho Plant Materials Center. Breeder plants will be maintained at the Upper Colorado Environmental Plant Center (UCEPC) Meeker, Colo. Recognized classes of plants will be breeders, foundation, and certified. All certified seed will be produced from foundation cuttings to establish certified seed orchards. Certified containerized plants can be produced from certified seed. Request for foundation vegetative material should be directed to the Colorado Seed Growers Association or the Utah Crop Improvement Association.

Ephraim Crested Wheatgrass

Intermountain Forest and Range Experiment Station and Soil Conservation Service, Utah State Division of Wildlife Resources, and the Agricultural Experiment Stations of Utah, Arizona, and Idaho released Ephraim crested wheatgrass (*Agropyron cristatum* L., Gaertn.). Ephraim was introduced from Ankara, Turkey.

Ephraim is rhizomatous and has shown good characteristics primarily for stabilization of disturbed sites, critical area stabilization and erosion control. It is equal to standard crested wheatgrass for range forage.

Ephraim will grow and produce adequate forage with 8 inches annual precipitation. It does best between 10 and 14 inches. The higher the precipitation, the sooner the rhizomatous characteristics develop. It is adapted to a wide range of soils, including disturbed areas and mine spoils. Salt and alkali tolerance is moderately high. It is not well adapted to silty soils having a very low water intake rate or extremely stony sites. When in pure stands it is susceptible to the black grass bug, *Labops hesperus*.

Breeder plants will be maintained by the Aberdeen Plant Materials Center, Aberdeen, Idaho, which will have responsibility for production of foundation seed. Recognized classes of seed are breeder, foundation, registered, and certified. Foundation seed is available though local soil conservation districts and agricultural experiment stations. Certified seed should be available in the fall of 1984.

Paiute Orchardgrass

Intermountain Forest and Range Experiment Station and Soil Conservation Service, Utah State Division of Wildlife Resources, and the Agricultural Experiment Stations of Arizona, Idaho, and Utah released Paiute orchardgrass (*Dactylis glomerata* L.). Paiute was introduced from Ankara, Turkey, in 1934.

Paiute is a persistent bunchgrass adapted to arid rangelands in the Intermountain West. It was selected for its ability to establish and persist in areas down to 11 inches of annual precipitation.

Paiute is a cool-season, shade-tolerant, long-lived bunchgrass that has an abundance of basal leaves and leafy upright stems. Under range conditions, Paiute usually develops distinct clumps and flower culms 15 to 18 inches tall, with leaves 10 to 12 inches long.

Paiute was developed as a forage crop for arid rangelands. It has good potential for erosion control, firebreaks, and critical area treatment. Livestock, big game, and rabbits have shown particular preference for Paiute. In comparison with standard crested wheatgrasses, Paiute greens up a week to 10 days earlier in the spring, remains green longer, responds quicker to fall rains, and is the preferred species for livestock and wildlife.

Throughout the Intermountain West, Paiute has done well on well-drained, basic to slightly acidic soils ranging from clay to gravelly loam, shallow to deep soils. Areas of greatest adaptability are the sagebrush-grass and pinyon-juniper communities.

Breeder seed will be maintained by the Aberdeen Plant Materials Center, Aberdeen, Idaho. Recognized classes of seed are breeder, foundation, registered, and certified. Certified seed should be available in the fall of 1984.

Stephen B. Monsen, *Chairman*

Equipment required to harvest seed from cultivated fields and native or wildland stands is needed. Various native and introduced herbs and shrubs are currently being developed for range and wildland plantings. The culture and harvest of seeds from these species requires special equipment. Backpack seed harvesters and field type combines are being used to collect seed from various species.

To date, the Seed Harvesting Workgroup has developed and field tested various backpack harvesters. All have usefulness in collecting seed of various species. No machine is universally adapted to harvest seeds of all plants. However, the "Elephant-Vac," a large commercial vacuum, has performed satisfactorily. The unit is large enough to develop sufficient suction to remove and draw large seeds of fourwing saltbush and other related seeds into the collection unit. This collector must be transported on a pickup truck, which somewhat limits its usefulness on steep or inaccessible sites. The machine does not damage collected seeds as the seed does not pass through the blower. The machine is easy to operate. The unit has potential in harvesting seeds from shrubs grown under cultivation. It is particularly useful in collecting lightweight seeds. It has also proven useful in harvesting seed from shrubs such as shadscale saltbush and spiney hopsage.

The Soil Conservation Service, Aberdeen, Idaho, is currently designing and developing a seed collector to harvest seed from field-grown crops, particularly of fourwing saltbush and other dry fruited seeds.

Elephant-Vac seed collector in operation.

Woodward Flail-Vac Seed Stripper–Update

By C.L. Dewald, Agricultural Research Service, Woodward, Okla.; V.A. Beisel, Aarons Engineering, Fargo, Okla.

During 1982, the first year of commercial use, 29 Woodward flail-vac seed strippers were manufactured and sold. These strippers harvested in excess of 60,000 pounds of pure live seed of Caucasian, WW-Spar, plains, and ganada bluestem during the first season of use.

Most of the harvesters manufactured were 7 to 10 feet in width for mounting on a front-end tractor loader. Two 14-foot-wide strippers were adapted for and mounted on cotton stripper chassis.

Seed is conveyed directly into the cotton stripper basket through duct work by the upward rotating flail-vac stripper brush and the airflow generated by the brush. The large seed basket of the cotton stripper reduces the need for frequent seed dumping, resulting in an increased rate of seed harvesting. Other jumbo seed strippers are being manufactured that utilize a large seed bin carried on the rear of the tractor by the three-point hitch. Seed is conveyed from the front-mounted stripper through flex tubes over the top of the tractor and down into the rear-mounted seed bin.

The success achieved by the Woodward flail-vac seed stripper is a result of its simplicity, effectiveness, and versatility.

For more information contact:

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or

Inventor (patent pending):

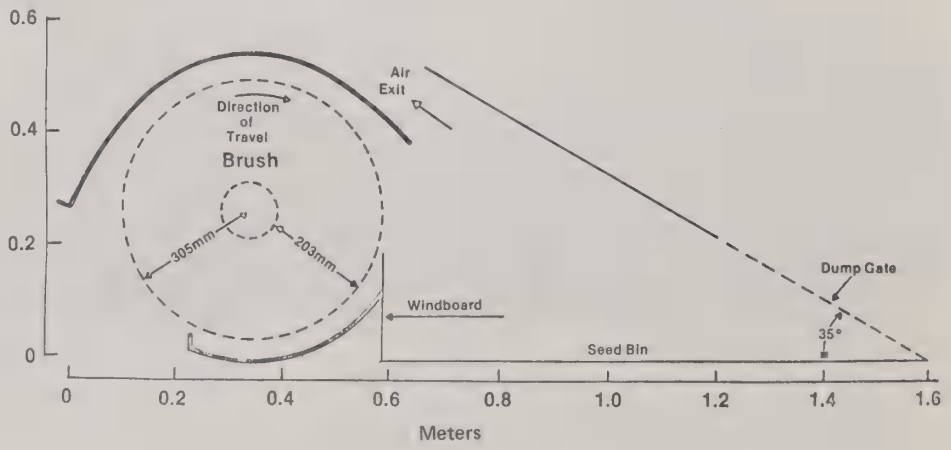
V.A. Beisel
Aarons Engineering
Fargo, OK 73840
(405) 698-2613

or

Manufacturer:

Ag-Renewal Group
Exchange Center II
Suite 403
4608 South Garnett Rd.
Tulsa, OK 74145
(918) 627-0727

Woodward flail-vac seed stripper being carried by a front-end tractor loader.



Cross sectional diagram of the Woodward flail-vac seed stripper with component dimensions.

Bob Hamner, *Chairman*

The level of workgroup activity this year has been low. Completion of work on the steep slope seeder and on the shrub planter has fulfilled the mandate of the workgroup. There have been numerous requests for information concerning availability of this equipment—particularly the steep slope seeder and copies of the Equip Tips ("Steep-Slope Seeder for Roadside Slope Revegetation," February 1979, SDEDC) containing performance and technical data. This information has been provided to those requesting information.

The low level of activity has led the workgroup chairman to review with the VREW workshop chairman and the Steering Committee the need for the workgroup at present. Several alternatives have been suggested and reviewed:

- Continuation of the workgroup as structured.
- Reduce the workgroup to a caretaker group of two or three individuals who will continue the present mandate and search for new equipment to meet present and new requirements.
- Dissolve the workgroup completely, or merge it into another workgroup, until such time as a need again arises for focusing on steep slope stabilization. This workgroup could be merged into the Disturbed Land Reclamation Workgroup.

No action has been taken to effect any of these alternatives. With the aid of the VREW workshop chairman and the Steering Committee, a decision will be made before the 1984 meeting on what action to take.

Disturbed Land Reclamation (Western Subgroup)

Ron Younger, *Chairman*

(Reported by Thane Johnson (BLM retired), Appleridge Realtors, Lakewood, Colo.)

Western Reclamation Group Progress Report—1982

By Wayne E. Sowards, Trapper Mining, Inc., Craig, Colo.

(Reported by Thane Johnson (BLM retired) Appleridge Realtors, Lakewood, Colo.)

The Western Reclamation Group was formed in 1981 by representatives of the coal mining industry, environmental consultants, State regulatory agencies, and universities. The group formed in response to existing and incipient regulations, guidelines, and policies for the standards of revegetation for coal mined lands. The specific objectives of the group include:

1. Promoting a cautious and deliberate approach to establishing reclamation standards.
2. Evaluating the validity and applicability of current concepts for determining reclamation success.
3. Promoting new concepts for evaluating reclamation.
4. Promoting flexibility for use of a variety of reclamation standards.
5. Promoting the use of economical indices of reclamation success.
6. Promoting the use of reclamation standards that are relevant to the end land use.
7. Promoting reclamation standards that support multiple land uses.
8. Providing a forum for the interstate exchange of revegetation information.

The Western Reclamation Group has evaluated the regulations, policies, and guidelines for revegetation success standards of six Western States and the Denver Office of Surface Mining. The six States are Colorado, Montana, New Mexico, North Dakota, Utah, and Wyoming. The evaluations were made by four working subgroups to consider four major topics: (1) land use determinations and classification; (2) management of reclaimed lands; (3) quantitative evaluations procedures; and (4) concepts of reclamation standards. These topics were selected during a Western Reclamation Group workshop in Denver in October of 1981 when the subgroups were formed.

The subgroups presented their preliminary findings at the Western Reclamation Group workshop held in Denver in April 1982. The comments elicited from the workshop were used to finalize the findings and conclusions of the group.

These materials are directed to all persons involved in planning, studying, or administering standards of revegetation success for mined lands.

The Western Reclamation Group publication will be available through the Colorado State University Range Science Department in the late spring of 1983. Those interested in obtaining a copy should contact Edward F. Redente at (303) 491-6541 or by writing to: Department of Range Science, Colorado State University, Fort Collins, CO 80523.

Several overall observations and conclusions have been endorsed by the Steering Committee and are enumerated below:

1. Greater flexibility is needed in setting and administering revegetation success standards.
   - Several of the practices allowed or required for collecting and interpreting vegetation data vary significantly from State to State. These differences do not appear to be based on conditions unique to particular States or on technical or economic merit. Instead, they appear to reflect the individual preferences of the regulatory agencies. For example, the control area concept is mandated in Wyoming while Colorado uses the reference area concept and disallows using the control area concept. New Mexico encourages using the historic record concept but also allows using the reference area concept. However, none of the concepts have been proven valid. Regulatory agencies should only prevent the use of alternatives that are shown to be inferior.
   - The current approaches require excessive and costly sampling. Further, they require testing for success using confidence levels and intervals that may exceed sampling precision. Therefore, alternative quantitative procedures for vegetation data collection and interpretation should be allowed.
   - The requirements for achieving approximate original contour should encourage topographic variation within the reclaimed areas, leaving sections of highwalls, and leaving impoundments in portions of final pits where such actions enhance the postmining land use. The existing statutes and regulations should be changed to allow this alternative.
   - Bond release schedules should reflect the approved postmining land use. Croplands, haylands, and cultivated pasture lands, for example, should qualify for bond release in a much shorter period of time than the 10 years generally required by statutes and regulations in the Western States. The statutes should be modified to allow bond release in less time when appropriate.
2. Revegetation success standards based on premine conditions are not always suitable and may preclude the best possible reclamation.

- Concepts commonly used for establishing revegetation success standards, i.e., reference areas, control areas, and historic record, are unproven and require imitating the premine conditions. They are inappropriate when the postmining land use differs from the premine use or when utility can be improved by changing the vegetation. Their continued use discourages alternative land uses and reclamation planning to improve land utility. Means of establishing revegetation success standards that are not based on imitating the premine vegetation need to be developed and used where appropriate.

- Reclamation planning and practices are made subservient to quantitative revegetation success standards that rely on imitating the premining vegetation and land use. Such standards do not result from careful consideration of opportunities to improve the land and do not necessarily lead to optimum or cost-effective reclamation. There is a unique opportunity during reclamation to alter and improve land utility. For example, rangeland might be reclaimed to improved pastureland or dense stands of shrubs may be thinned or eliminated. These kinds of changes should be encouraged along with the establishment of standards that do not rely on imitating the premining conditions.

- Historic land use classification systems are not always appropriate to use in the West. Current regulatory approaches emphasize returning the premine land use even though it may be less appropriate or desirable than an alternate use. Therefore, the determination of the postmining land use should be based on the land capability and land use needs of the local area.

3. Reclamation planning decisions should be based on satisfying a primary land use objective.

   - Where the primary postmining land use is for livestock, few if any shrubs may be desirable. Other uses, such as wildlife, should be secondary and incidental and should not be the determinant for a postmining shrub standard. Where population-limiting wildlife habitat occurs, a shrub standard may be desirable that is optimum for wildlife species with livestock use considered secondary or incidental.

4. Most of the requirements for setting revegetation success standards and evaluating revegetation success are based on guidelines and unwritten policies.

   - Much of the statutory language is qualitative and does not necessarily denote specific technical interpretation. Examples of such language include "approximate original contour," "predominantly native species," and "permanent, effective, and diverse vegetative cover." These phrases have been translated into regulations, guidelines, or policies that are highly quantitative and often inflexible and unproven, e.g., a diversity index. Such quantitative procedures are not specifically required by the statutes. The regulatory process has resulted in these interpretations taking on the force of law. The reluctance of regulatory agencies to approve revegetation success criteria without reference areas is an example, even though the law does not mandate any particular approach. This regulatory discretion should be used to allow and encourage alternative approaches.

Land Imprinter Results in Utah

By Warren P. Clary, Forest Service, Provo, Utah;
Thane J. Johnson, BLM (retired), Salt Lake City, Utah

At the 1982 Vegetative Rehabilitation and Equipment Workshop, Thane Johnson described a study to be conducted by the Intermountain Forest and Range Experiment Station and the Utah State Office of the Bureau of Land Management. This study was a comparison of the revegetation effectiveness of a locally constructed land imprinter and a conventional rangeland drill. An unseeded comparison was also included in the test (VREW 36th annual report, page 16).

The study site was established in October 1981 on the Little Oak Creek Burn, which occurred in July 1981 in central Utah. The treatments of imprinting and drilling, and the "no seeding" control were each replicated twice. Treatment strips were 500 feet wide and 1 mile long. The seed mixture applied by both imprinting and drilling consisted of Fairway crested wheatgrass (4 lb/ac), Luna pubescent wheatgrass (1½ lb/ac), Russian wildrye (2 lb/ac), and Ladak alfalfa (½ lb/ac) for a total seeding rate of 8 pounds per acre.

In each treatment strip, three transects of 10 1-m^2 plots in each of three fine sandy loam to silt loam soils were used to sample seeded and native herbaceous vegetation. In addition, steel stakes with reference marks were established at each transect so soil losses could be monitored.

The results are only a preliminary examination of the treatment responses after one growing season and, therefore, should be considered in that light. Wind erosion was severe on all treatment strips. Soil depth losses reached 6 to 8 inches in local situations; however, average soil depth change (which included areas of wind deposit) appeared to be less than 1 inch.

Seedling establishment was not spectacular under the difficult erosion conditions, but several results are suggested by preliminary data. The initial seedling composition contained wheatgrasses in a greater proportion than their proportion by weight in the seed mix. Alfalfa's initial establishment was in proportion to its weight in the seed mix; no Russian wildrye was identifiable the first growing season.

Seedling densities are shown in table 1. Although the densities attained under conditions of this study were not high, the first-year results suggest a significantly greater establishment of species seeded by the land imprinter than by the rangeland drill. Total seedlings established by the imprinter planting exceeded those established by the drilling by over three times in our sample. Crested wheatgrass in the imprinted area was

over four times the density of that in the drilled area, although the true population ratios may vary considerably from these estimates as suggested by the confidence intervals. No evidence has been obtained to suggest that the treatment areas differed in the amount of soil erosion, and no signficant differences in plant establishment were apparent among soils.

Native plants were highly variable in their initial regrowth within the treatment strips. Further study will be made of the relationship of native plant response to seeding treatments.

Table 1.—*First growing season densities of seeded species on the Little Oak Creek burn (number 10 ft^2)*

Species	Seeding treatment		Ratio of densities	Confidence interval of ratio
	Imprinting	*Drilling*		
Crested wheatgrass	3.6	0.8	4.5	1.3-51.1[1]
Pubescent wheatgrass	1.3	0.6	2.2	0.1-23.6
Russian wildrye	0	0	–	–
Ladak alfalfa	0.2	0.1	2.0	0.7-6.5
Total	5.1	1.5	3.4	1.2-18.4[1]

[1] These confidence intervals represent significant differences between treatments. Calculation based on logarithmic transformation.

In conclusion, initial results from the Little Oak Creek Burn in central Utah suggest significantly better establishment of seeded forage species planted by the land imprinter as compared to the more conventional rangeland drill under our conditions of severe wind erosion. Further measurements and observations will be made before final conclusions are reached regarding relative seeding success and native plant response.

Disturbed Land Reclamation (Eastern Subgroup)

Willis G. Vogel, *Chairman*

This report includes: (1) a discussion of problems and concerns with establishing woody vegetation on Eastern surface mines and the use and needs for equipment related to those problems; (2) a list of equipment currently used in revegetating Eastern surface mines; and (3) a possible means for VREW to disseminate information.

Problems with Establishing Woody Species on Eastern Surface-Mined Lands

One of the current problems in revegetating surface mines in the Eastern United States is the inability to successfully establish trees and shrubs for forest and wildlife habitat post-mining land uses. Curiously, the declining success with tree planting seems to coincide directly with the enactment and enforcement of surface mining laws and regulations that require (1) intensive grading and shaping to approximate original contour ; (2) replacement of surface soils; and (3) the quick establishment of herbaceous cover for controlling erosion. For comparison, most of the successful tree plantings made 20 to 50 years ago were on cast overburden that was not graded, not topsoiled, and not seeded to herbaceous species. Today, tree growth on some of those sites exceeds that in nearby unmined forests.

Part of the problem that hinders reforestation efforts, especially, is soil and spoil compaction that results from the intensive grading and soil replacement processes. Most of the studies and observations made through the years have shown that tree survival and growth is better on ungraded than on graded spoils. In some plantings, differences in tree size are still obvious 40 years after planting. In some regions, surface soils used for "topsoiling" are less suitable as a rooting medium than are some of the overburden materials even those containing coarse fragments. When being replaced the fine-textured soil materials can be compacted, which causes poor water entry, shallow root penetration, higher rates of runoff, and excessive erosion. Herbaceous cover is needed for erosion control, but it can accentuate periodic moisture stress and may produce allelotoxins and excessive shade that contribute to poor survival and growth of small tree seedlings.

I see no apparent need for designing new equipment or even modifying existing equipment for overcoming the problems with compaction and replacement of surface soils. Some of the problems can be avoided by using different equipment and different methods for moving and placing overburden, especially the topsoil and subsoil materials, and with minimal grading of the replaced materials. Present technology in replacing and grading soil materials is too often similar to that used in road construction where compaction is the objective. An alternative method of hauling soil in trucks, dumping it in windrows, and spreading it with low pressure tractors is preferable to the technique of laying down soil in relatively thin layers with scrapers.

Some of us involved in reclamation believe, contrary to popular and some scientific opinion, that coarse fragments can be a valuable part of the plant growth medium, especially where woody vegetation is to be planted. Spoil containing coarse fragments blended with the surface soils might make the replaced soils less subject to compaction and possibly more productive even for some agricultural uses. But, coarse fragments obviously can interfere with the use of standard farm machinery especially that used for planting, cultivating, and harvesting row crops.

The problems with the interference of competition of herbaceous cover in establishing woody species can perhaps be alleviated with specially designed and modified equipment. The interests and efforts of our Eastern Subgroup will be directed toward (1) assessing techniques for establishing woody species and herbaceous cover together; and (2) investigating the current use of and needs for equipment to help achieve better survival and growth of woody species planted with herbaceous cover species.

At present, some of the larger mining companies that are committed to reestablishing woody vegetation on part of their mined areas are taking the lead in modifying and adapting equipment for applying herbicide in conjunction with their tree planting operations. For example, Amax Coal Co. in Illinois and Indiana uses a sprayer attached to a mechanical tree planter for applying herbicide at the same time that trees are being planted.[1] They find that the increased survival of trees in treated strips pays for the added cost of spraying due to the fewer number of trees that need to be planted initially and to the unneeded cost of replanting. This concept is not new. A similar mechanical planter-sprayer combination has been developed and recently reported on in *Tree Planters' Notes* by the Virginia Division of Forestry.[2]

Another procedure is to spray herbicide in strips or in spots ahead of tree planting. A waiting period is required for the herbicide to take effect so that one can see where the trees should be planted. Mechanical sprayers can be used for strip application but to my knowledge spot treatments must be done by hand spraying. Hand spraying would be necessary and advantageous on steep slopes, but on more level areas a mechanical sprayer modified to spray in spots seems appropriate.

Mechanical control of herbaceous cover also has been tried but it has not always been as effective as chemical control. Normally, mechanical control is done in continuous rows or strips. The Hodder gouger could be modified specifically for mechanically controlling herbaceous cover in spots.

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[1]Parr, D.E. 1982. Reforestation as a post-mining land use in the midwest. *In:* Proc. Symp. on Surface Mining Hydrol., Sedimen., and Reclam. UKY BU 129, Coll. of Eng. Univ. of Kentucky, Lexington. pp. 249-256.

[2]Garner, J.W. and H.L. Olinger. 1982. Modification of a tree planter to include herbicide application. Tree Planters' Notes. Summer 1982. pp. 13-14.

My personal choice of procedures is to plant trees and herbaceous cover at the same time. One approach is to use cover species that provide the least amount of competition to trees. The other approach is to sow herbaceous cover in strips that alternate with unseeded strips in which woody species are planted. Where used on sloping areas the strips must run on contour. Obviously this procedure could not be applied by mechanical means on steep slopes. For areas accessible to vehicular traffic, I envision that equipment can be designed or modified to accomplish the seeding, fertilizing, and tree planting all in one operation.

Direct seeding of woody species is a method most sought after by mine operators in the East. So far, establishment of only a few species of woody plants has been consistently successful by direct seeding. Fair success generally has been obtained from direct seeding some of the large-seeded species such as red oak and bur oak, but equipment for mechanically seeding these large seeds is not available, or at best under development. At last year's VREW meeting Tom Richards reported on his work to modify a row crop planter for planting large seeded tree species. A tree seeder may be a natural to fit into a piece of equipment designed for the strip seeding-planting concept mentioned above.

Damage by wildlife, especially by small mammals and deer, is another cause of failure in establishing woody species. Small mammals such as field mice and voles pilfer tree seed and gnaw bark on small tree seedlings. Rabbits clip off and debark tree seedlings. Dense herbaceous vegetation adds to the problem because it provides ideal cover and nesting for many of these mammals. In some areas success with tree planting is nearly impossible due to browsing by deer. Prevention of or solution to wildlife damage probably cannot be provided by equipment development, although application of repellents may utilize existing equipment.

Equipment Used in Revegetating Eastern Surface Mines

The following equipment used in revegetating surface-mined lands in the Eastern United States is ranked more or less in order of most to least used. The order will vary in different regions.

Equipment	Function
Dozers	Prepare seedbed by "tracking in" and "backblading"
Hydroseeder	Apply seed, fertilizer mulch, hydrated lime; especially useful on steep slopes
Rippers	Break up compacted soils, especially below tillage depth
Disk Standard Heavy duty	Prepare seedbed, incorporate lime, break up compacted soils (surface). Standard farm disks probably used more than heavy-duty ones
Power mulcher	Apply straw and hay mulch
Rotary spreaders (Cyclone seeders)	Apply seed and fertilizer
Standard lime spreader	Apply agricultural lime, fertilizer
Drills (grain, grassland, rangeland)[1]	Apply seed
Krimper	Anchor straw and hay mulch
Estes spreader	Apply agricultural lime, fertilizer, mulch on steep slopes and level areas
Chisel plow and field cultivator	Prepare seedbed and incorporate lime
Manure spreader	Apply barnyard manure, bark, and woodchip mulches
Spike tooth harrow	Prepare seedbed; smooth rough soil surfaces
Row crop planters	Seed row crops on reconstructed prime farmland
Mechanical tree planter	Plant tree and shrub bareroot seedlings
Klodbuster	Prepare seedbed on steep slopes
Rotogrind tub mulcher	Apply straw, hay, and other organic mulches
Herbicide sprayers	Control herbaceous cover that competes with trees
Bedding disk	Construct low terraces
Leveling bar	Smooth rough soil surface, prepare seedbed

[1] Popularity of some equipment varies in different regions. For example, the hydroseeder is used on nearly every mine in the Appalachian Mountain region, but seldom used in the interior or midwestern coal regions. Conversely, drills are used more in the Midwest than in Appalachia.

Information Dissemination

One recommendation by the Exploratory Committee is for VREW to publish single item technical notes and development papers throughout the year to keep users informed. One possible means to assist in dissemination of VREW information is through Don Eagleston, information transfer specialist on surface mine reclamation, State and Private Forestry, USDA Forest Service, Rt. 2, Berea, KY 40403. Don publishes a monthly newsletter called "RecTec" in which recent publications, notices of meetings, etc., related to surface mine reclamation are listed. His mailing list exceeds 3,700 names (mining industry, government agencies, universities, etc.), about 600 to 700 in the Western States. If you list a publication in "RecTec," expect to receive as many as 100 to 500 requests for reprints.

Thermal Plant Control

Bill Davis, *Chairman*

No report submitted for publication.

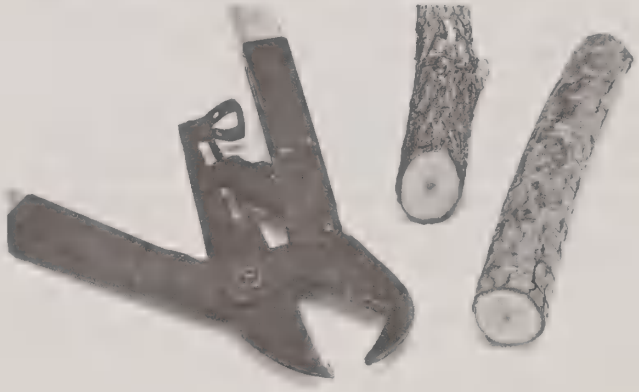
"Homemade" spike-tooth harrows prepare a seedbed on the Dixie National Forest, 1940.

Mechanical Plant Control

Loren Brazell, *Chairman*

(Reported by Gus Juarez, BLM, Grand Junction, Colo.)

The Mechanical Plant Control Workgroup has become aware of a hand-operated, ratchet lopping shears that will cut up to 2-inch stems, requiring only moderate effort. In field trials, they have worked very well. They are available from American Standard Co., 1 West St., Plantsville, CT 06479, (203) 628-9643.



Hand-operated ratchet lopping shears will cut up to 2-inch stems using only moderate effort.

Land Treatment By Chaining on the Dixie National Forest

By Frank R. Jensen, Dixie National Forest, Cedar City, Utah

The Dixie National Forest has reseeded approximately 145,000 acres of formerly depleted rangelands. This reseeding program was started around 1940 using teams of horses to pull "homemade" spike-tooth harrows. As range seeding and rehabilitation equipment has been developed under the auspices of VREW, much of it has been used on the Dixie National Forest. This equipment includes pipe harrows, brushland plows, offset disks, rangeland drills, and various types of modified anchor chains. Much of the 145,000 acres seeded on the Dixie National Forest were prepared for seeding with modified anchor chains, aerial seeded, then chained a second time to cover the seed.

Modified anchor chains are an effective site preparation tool for rough, rocky rangelands covered with sagebrush, partial pinyon-juniper, and oakbrush. However, there is little advantage in using modified anchor chains in dense, mature pinyon-juniper stands as "smooth" chains work adequately and pull much easier in this type of stand. It also needs to be emphasized that modified anchor chains are not plows. If complete vegetation control is desired, rehabilitation equipment other than modified anchor chains should be used. A number of different chain lengths, chaining patterns, types of digger teeth, swivels, and clevises have been tried on the Dixie National Forest. From these experiences, the following is recommended:

1. Total chain length of approximately 250 feet and weighing about 15,000 pounds.

2. Pull the chain in a "U" pattern with tractors no more than 75 feet apart. If a more complete job of site preparation is desired, move the tractors into ■ 50-foot swath. Swath width is very important. The narrower the swath, the greater the degree of vegetation uprooting and seedbed scarification. Allowing the tractors to move too far apart, i.e., 100 feet or more, is usually the most common error made in using modified anchor chains. Swaths greater than 100 feet do not result in adequate uprooting of vegetation or seedbed scarification.

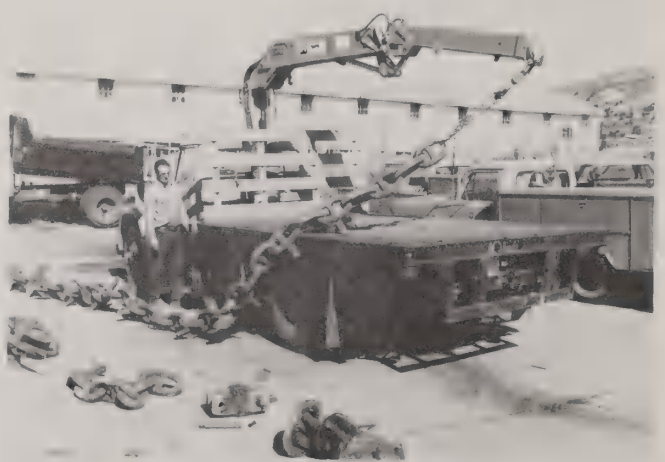
3. Approximately 175 chain links should have digger teeth. There should be approximately 45 feet of smooth chain on each. The swivel should be placed at the connection between the smooth chain and the digger teeth equipped chain. This helps prevent the tractors from backing over the swivels when they are turning around.

Swivels are made from used D-9 Caterpillar tractor track rollers. The "jaws" in front are made from 1-inch steel plate. A D-7 Caterpillar tractor drawbar pin is used to attach the chain. Four links of chain are used on the trailing end with one being cut, fitted, and welded to the roller chaft. A zerk grease fitting is installed in the center of the roller and protected by welding ■ guard over it.

D-8 Caterpillar tractors pulling a modified anchor chain to prepare ■ seedbed on the Dixie National Forest, 1980.

Clevis/connecting links are made from 1½-inch steel plate. They are 16-inches long and use D-7 Caterpillar tractor drawbar pins. A ½-inch bolt through the bottom of teh drawbar pin holds it in place.

Many types and designs of digger teeth have been tried. The best "all around digger teeth are made using 18-inch-long railroad rails with the "foot" cut off and welded to the chain link. If the foot is not cut off, the chain will not "clean" itself of debris well. The chain links are 2½ inches in diameter and weigh 60 pounds per foot.



Truck used to transport chain. A crane-equipped truck has proven to be very effective in transporting the chain and maneuvering it to weld on digger teeth and change swivels and clevis connection.

Ray Dalen, *Chairman*

A handbook on aerial herbicide application is being prepared and is in the final stages of draft completion. Some updating and review is awaiting funding and the issuing of a purchase order to the University of California at Davis for work to be done by Dr. Norman B. Akesson.

Ground Sprayers for Sagebrush Rangelands

By James A. Young, Agricultural Research Service, Reno, Nev.

Introduction

The use of herbicides to control brush and weeds, to release forage species, or to allow the seeding of desirable forage species is a valuable range improvement technique. Herbicides usually are applied aerially on rangelands because of their extensive and often rugged terrain. For small acreages, in remote locations, it is often impossible to obtain aerial applicators. This report describes modifications of power-ground sprayers to permit their use on rangelands. The modifications to booms, boom supports, and suspension can be done in typical farm shops. Techniques for calibration and tips for operating rangeland sprayers are also given.

Sprayer System Design

In choosing or designing a sprayer for use on sagebrush rangelands, one should consider the various essential elements of a power sprayer, i.e., nozzles, boom, pump, power unit, and tank, and their compatibility and the acreage to be sprayed, the sprayer application rate, and the terrain to be sprayed.

Pumps

The heart of any herbicide sprayer system is the pump. The more common types of pumps include roller, centrifugal, diaphragm, and piston. Each type of pump has advantages and disadvantages in terms of initial cost, repair cost, and efficiency. A general-use pump is the centrifugal, or turbine-type, pump. Centrifugal pumps develop pressure by creating centrifugal forces on the water as a result of the rapidly rotating impeller. As clearances are relatively large in centrifugal pumps, suspended solids (such as wettable powder herbicides) do not damage them. Single-stage centrifugal pumps must be operated at relatively high speeds. For this reason, centrifugal pumps cannot be directly driven by a power takeoff from a tractor. However, several companies now manufacture centrifugal pump kits with belt-drive arrangements that can operate centrifugal pumps on either the new 1,000-rpm or the standard 550-rpm power takeoff. In the Midwest, this type of sprayer is very popular.

Pump Size

The required pump rating is determined by the number of nozzles, their size, and hydraulic agitation requirements. The standard formula used for calculating sprayer output is:

$$FR = \frac{AR \times S \times W}{5{,}940}$$

Where:
- FR = flow rate, in gallons per minute of pump
- AR = sprayer application rate, in gallons per acre
- S = speed, in miles per hour (mph)
- W = width sprayed, in inches (in)
- 5,940 = a constant.

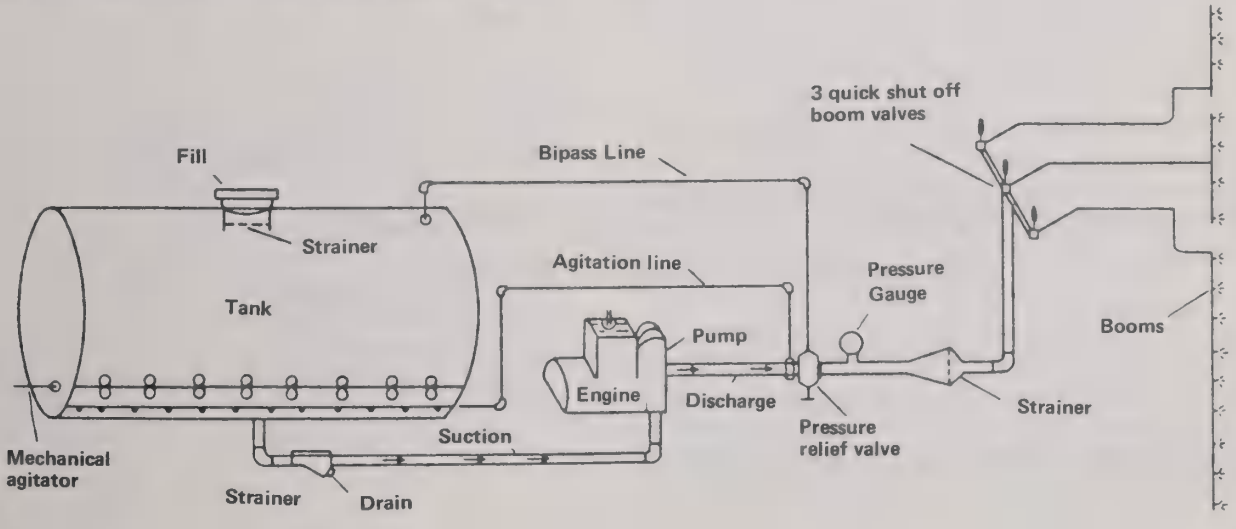
Example:
- AR = 15 g/a
- S = 1.5 mph
- W = 35 ft or 420 in

Therefore:

$$FR = \frac{15 \times 1.5 \times 420}{5{,}940}$$

$$= 1.59 \text{ g/m.}$$

An important factor in determining required pump rating is the type of agitation used in the spray tank. If hydraulic agitation is used, a larger pump rating is required. In hydraulic agitation, a pump of considerably higher rating than that required to supply the boom is used; the excess flow being bypassed into the spray tank through a series of holes in a pipe located at the bottom of the tank.



Components of herbicide sprayer.

In rangeland spraying, the sprayer application rate (AR) should be kept as low as possible because of the cost of hauling water. As a tolerance factor, AR can be set at 75 g/a, or five times the 15 g/a used in the equation. This makes the maximum pump rating 7.92 g/m, or 8 gpm. This does not require a very high flow rate pump. The pumps of almost all farm sprayers will meet this requirement of 8 gpm.

Power Unit

The sprayer can either be powered from the towing tractor pto or a separate engine. If one is buying an assembled sprayer, the manufacturer should provide a power unit of adequate horsepower to drive the pump; if one is assembling a sprayer, he or she will want to determine the power requirement of the pump being used. The pump manufacturer will usually furnish charts showing horsepower requirements at various pressure and discharge rates.

Spraying sagebrush rangeland involves operating the sprayer power unit under extremely dusty conditions. If a separate engine is used, it should have a good quality, preferably oil bath, air cleaner. The exhaust system and muffler should be so designed to avoid a fire hazard from accumulations of sagebrush leaves and trash. Installing a spark arrester will reduce the hazards of the exhaust starting fires. The engine for a rangeland sprayer should start easily after long periods of storage and exposure to the elements. Also, the spray unit should be equipped with an adequate size gasoline tank so the unit will not run out of gasoline before running out of herbicide.

Booms

A 35-foot boom is a practical maximum for spraying sagebrush rangelands. Longer booms are possible if proportionally more massive modifications are made; however, considering the terrain and the maneuverability required, the 35-foot boom appears to be an upper limit.

Boom Support

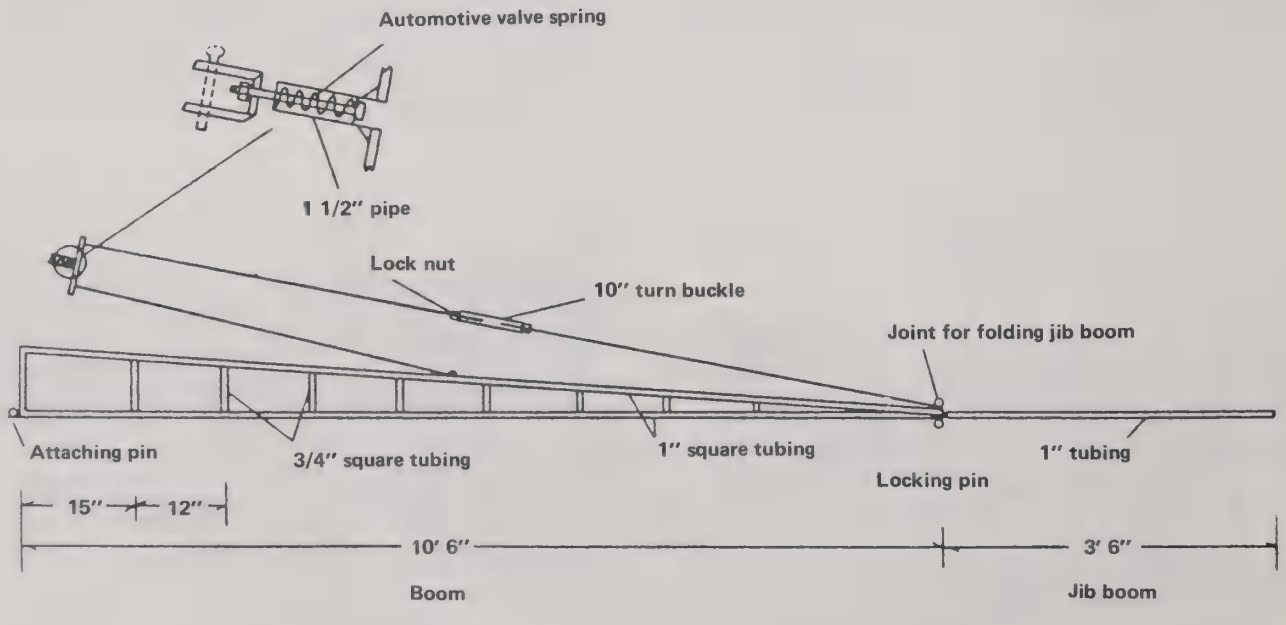
When spraying sagebrush rangeland, the boom must clear the sagebrush and also not be driven into the ground when a wheel of the sprayer drops into a hole, or the opposite wheel is raised by a rock or other obstruction. This requires the boom to be mounted about 5 feet above the ground when spraying 1- to 3-foot-tall sagebrush.

Boom Types and Construction

The booms supplied with sprayers are often constructed on 1-inch-diameter steel tubing. On most spray units, this steel tubing only provides support for hoses that distribute the herbicide solution to the nozzles. This type of boom is called a dry-type boom.

The standard sprayer booms furnished with farm spray units have proven unsatisfactory for operating in sagebrush rangeland. The constant flexing of the metal tubing as the trailer bounces over rough ground causes the tubing to first bend, then break.

On booms that have proven satisfactory, the main booms are designed as a tapering lattice with the top and bottom constructed of 1-inch square tubing. (Even a stronger boom could be constructed by dividing the lattice up into triangles.) The interior supports were constructed of 0.75-inch square tubing alternating with 0.5-inch square pieces to reduce weight.



Lattice boom, suspension rods, and shock absorbers for sagebrush rangeland sprayer.

As compared with round tubing, the square tubing improves the strength-to-weight ratio and makes welding easier. The nozzle mounting will have to be changed from fitting round tubing, to fitting square tubing. The center section will not require modification and can remain as 1-inch round tubing.

Boom Suspension
Equally important with strengthening the booms for operation on sagebrush rangelands, is changing the boom suspension to prevent flopping. Normally, the booms are suspended from the mast by chains or cables. When the trailer wheels bounce over rough terrain, the flexible suspension allows the booms to flop up in the air, and the resulting return shock breaks the booms and mast.

To prevent flopping of the boom, 3/8-inch-diameter rods can be substituted for the chains. For adjustment of boom level, a 10-inch turnbuckle can be placed in the longer rod. Each turnbuckle should be equipped with a locking nut to prevent turning.

Shock Absorbers
Improve shock absorbers can be made by using automotive-type valve springs inside 1½-inch pipe.

Breakaway
The bottom of the boom can be attached to the bottom of the primary boom support by a commercial, spring-loaded breakaway hinge. This is a safety feature to prevent damage to the boom when hitting an obstruction.

Tank
Spraying sagebrush rangelands does not require a special tank. Stainless and plastic tanks have been used successfully. A 300-gallon tank has proven adequate.

Agitation
The two basic types of agitation in sprayer tanks are mechanical and hydraulic. The mechanical agitator usually consists of a series of paddles on a shaft running through the tank.

As previously noted, in the hydraulic agitation system, a pump of considerably higher rating than that required to supply the boom is used. The excess flow is directed back into the spray tank through a series of holes in a pipe located at the bottom of the tank. Hydraulic agitation nozzles should be connected directly off the output of the pump and not supplied by the bypass line from the pressure relief valve; for the operation of a pressure relief valve assumes that the relief or bypass is to atmospheric pressure.

Generally, mechanical agitation requires less power and gives a more uniform dispersion than hydraulic agitation. The initial cost of mechanical agitators is greater. The double bypass hydraulic system has been found to be satisfactory even when spraying wettable powders. The rough terrain and obstructions encountered on rangelands result in severe bouncing of the sprayer and contribute to good agitation.

Hoses
Single-ply, 3/8-inch-inside-diameter hose has been found to be satisfactory. This hose can be purchased in bulk from sprayer manufacturers. All connections of hoses should be made with quick-disconnect coupling to simplify cleaning and removing.

Commerically manufactured nylon T's with tapered-barbed bodies can be used to attach nozzles in the spray lines. Bulk rolls of hose can be cut to any desired nozzle spacing.

Quick Shutoff Valves
On sagebrush sprayers with a 35-foot swath, there are usually three sections of booms, the right and left 14-foot boom and a 7-foot, 7-inch-boom across the rear of the trailer. In the front of the trailer, positioned so they can be easily reached from the tractor seat, should be three quick-shutoff valves controlling the tree boom sections. These valves allow independent control of each section of the boom.

Strainer
An in-line strainer with interchangeable screen should be mounted between the tank and the pump to protect the pump and to prevent undesirable material from reaching the nozzles. A strainer with interchangeable screen is necessary. When spraying, 2,4-D through nozzles with fine openings, a 100-mesh screen should be used, and when spraying wettable powders such as atrazine, a 40-mesh screen is required.

Pressure Relief Valve
A pressure relief valve should be placed in the main line before the quick-shutoff valves that control the booms. This relief valve insures that the desired pressure is maintained on the spray lines at all times. A pressure gage with suitable graduations is used to calibrate the relief valve. On high-pressure sprayers used for spraying livestock, the pressure gage may not have fine enough graduations for field spraying at low pressures.

Nozzles
Spray nozzles and bodies are manufactured in brass, aluminum, nylon, and stainless steel. Brass nozzles are most common. Nozzles that produce a flat, fan-shaped spray are considered better than nozzles that produce cone-shaped sprays because they give more uniform coverage and have a higher spray material velocity.

The nozzle flow rate (NFR), usually measured in gallons per minute, is determined by the diameter and type of orifice and pressure. The nozzle flow rates are given in tables supplied by manufacturers. The NFR and nozzle spacing on the boom are important because, in conjunction with the speed of the sprayer, they determine the application rate.

For open-field spraying, nozzles are usually spaced from 12 to 24 inches apart. The spacing of the nozzles is partially dependent on the angle of the spray fan. Nozzles are available in a variety of spray angles, but 65 and 80 degrees are most commonly used. The nozzle spacing for flat fan nozzles depends greatly on the spray angle. It is best to follow the recommendation that nozzle manufacturers suggest.

Nozzle Screens
When spraying 2,4-D through nozzles with small orifices, use fine 100-mesh screen in the nozzles. When the nozzles are switched to larger orifices for spraying wettable powders, the nozzle screens and in-line strainer screens must be changed to 40-mesh.

Sprayer Operation
The first step in sprayer operation is calibration. To the unfamiliar, this might appear a difficult operation, but approached on a step-by-step basis and understanding the principles involved leads to easy mastering of the procedure.

Speed
For sagebrush rangelands, 1.5 mph is the fastest practical speed. This may seem very slow, but at 1.5 mph, 132 feet are traveled per minute. At this speed, driving the tractor through heavy brush, around large rocks, and across drainage ways, while watching the spray coverage, will fully occupy the tractor operator.

Pressure
The nozzle flow rate (NFR) depends on the pressure. Because on rangeland spraying it is usually desirable to apply relatively low volumes of carrier, the pressure should be kept low.

Sprayer Application Rate
As previously mentioned, the NFR in gallons per minute can be determined for a particular nozzle and pressure from tables supplied by the manufacturer. For sagebrush spraying, a nylon nozzle with a stainless steel tip insert that delivers a NFR of 0.067 gpm at a pressure of 30 psi is satisfactory. Knowing the speed (1.5 mph), nozzle spacing (22 inches), and NFR (0.067 gpm at 30 psi), the sprayer application rate (AR) can be determined in gallons per acre:

$$AR = \frac{5{,}940 \times NFR\ (gpm)}{S\ (mph) \times nozzle\ spacing\ (inches)}$$

In our case, this would be:

$$AR = \frac{5{,}940 \times 0.067\ gpm}{1.5\ mph \times 22\text{-}in\ spacing}$$

$$= 12\ g/a\ AR$$

The AR can also be derived by an empirical method. Fill the spray tank to some determinable mark, such as the bottom lip of the fill hole. With the desired pressure set (30 psi) and driving the tractor at the desired speed (1.5 mph) drive 40 rods, or 1/8 mile with the system in operation. Measure the amount of water required to refill the tank to the same level. The gallons per acre actually sprayed can be determined by the following formula:

$$AR = \frac{Gallons\ used \times 66}{Length\ of\ boom\ in\ feet}$$

In our case, it would be:

$$AR = \frac{6.36 \times 66}{35} = 12\ g/a$$

Wettable Powders
The spraying of wettable powders (WP), such as the herbicide atrazine, presents special problems. The powdered herbicide does not dissolve, but is merely suspended in the spray solution. The orifice of the nozzle must be large enough to allow the particles of herbicide to pass through. The labels on bags of wettable powder herbicides contain a warning statement concerning the orifice size.

The minimum orifice size for nozzle tips for spraying atrazine is usually given as 13/64 or 0.043 inches. A 40-mesh screen must be used in the nozzles to allow the suspended herbicide to pass through.

The 13/64-inch orifice at 30 psi has a 0.26-gpm NFR. Our calculations for AR would be:

$$AR = \frac{5{,}940 \times 0.26\ gpm}{1.5\ mph \times 22\ inches} = 47\ g/a$$

This is a much higher volume than was used to spray 2,4-D. The higher volume is made necessary by the larger orifice size. The AR could be reduced by increasing speed or reducing pressure. However, it is not practical to run most spray systems below 30 psi, and when spraying rangeland, 1.5 mph is about as fast as a spray rig can be pulled.

Determining the Amount of Herbicide
Step One: *Read the Label!* The recommended range of application rates for the specific formulation is given on the label. Be sure the rate used is the appropriate one for the plants that are being sprayed. Normally, the label will list the pesticide application rate (PAR) per acre in pounds of active ingredient (a.i.). For example, 2 lb/acre a.i. of 2,4-D are generally recommended to control sagebrush.

Step Two: Determine concentration of active ingredient. The label will show the amount of active ingredient in each gallon of herbicide formulation. This amount is normally shown as pounds of active ingredient per gallon (for example, Acid Equivalent: 4 lb/gal).

Step Three: Determine the amount of herbicide to add to the tank as follows:

$$\text{Quarts of herbicide per 100 gal of mix} = \frac{\text{Desired herbicide application rate (pounds per acre)} \times 400}{\text{Active ingredient of herbicide (pounds per gallon)} \times AR\ (g/a)}$$

In our case:

$$\text{Quarts of herbicide per 100 gal of mix} = \frac{2\ lb/acre \times 400}{4\ lb/gal \times 12\ g/a\ AR}$$

$$= 16.7\ quarts\ per\ 100\ gal$$

For a 300-gallon tank, 50 quarts or 12.5 gallons of herbicide would be added and the tank then filled with water. Do not fill the tank first and then add the herbicide as this will exceed the capacity of the tank.

For determining the amount of a wettable powder (WP) formulated herbicide to add to the spray tank, a similar procedure is used, following the formula:

$$\text{Pounds of chemical per 100 gal of mix} = \frac{\text{Herbicide application rate (lb/acre)} \times 100}{\text{Percent WP} \times \text{AR (g/a)}}$$

For example, atrazine is usually applied at 1 pound per acre to control cheatgrass and has 80 percent active ingredient (80 percent WP).

$$\text{Pounds of atrazine per 100 gal of mix} = \frac{1 \text{ lb/acre} \times 100}{0.8 \text{ WP} \times 12 \text{ g/a AR}}$$

$$= 10.4 \text{ lb of atrazine per 100 gal of mix}$$

For the 300-gal tank, this amounts to 31 pounds of 80 percent WP atrazine or approximately six 5-pound bags.

Total number of acres that can be sprayed with one load can be determined by dividing the tank capacity by the AR, for example:

$$\frac{\text{300-gal tank capacity}}{\text{12 g/a AR}} = 25 \text{ acres per load}$$

Cleaning the Sprayer

The most important factor controlling ease of spraying is the cleanliness of the equipment. Sagebrush sprayers usually have a plastic tank, rubber hoses, and nylon plumbing and nozzle bodies. The only part not resistant to corrosion is the pump housing. The pump housing can be protected from corrosion when not in use by thorough flushing with clean water after spraying and then filling with antifreeze.

After spraying, the lines, plumbing, and tank must be thoroughly flushed with clean water. The nozzles and nozzle screens should be removed and washed in a mild detergent, thoroughly dried, and stored in plastic bags. The time spent cleaning is well worthwhile in avoiding clogged nozzles.

The openings in the nozzles are machined to close tolerances. If a nozzle is clogged, care must be taken not to enlarge the openings while cleaning. For fine nozzle tips, a wire from a 100-mesh nozzle screen can be used to remove obstructions.

Transporting the Sprayer

The bolt through the shock absorber and the pin at the base of the boom must be removed to detach the booms for transporting; however, due to the high clearance of the booms, it is sometimes possible to pass through rangeland gates without removing the booms; and sometimes, the wooden gate posts can be shortened (cut off).

Removal of the booms can be made easy by using quick-disconnect couplings in the spray hoses. This allows the boom, hose, and nozzles to be quickly detached as a unit.

Nurse Tank

It will do no good to clean the sprayer if it is filled with dirty water. A good nurse tank to supply the sprayer makes the job much easier. No herbicide should be allowed to contaminate the nurse tank. This is so the nurse tank can be used for hauling stock water and other uses. Most manufacturers of spray tanks also sell nurse tanks. Make sure the tank is clean and free of rust or scale before filling. Fill the tank with clean water. It is a good idea to place an in-line strainer between the nurse tank and the pump used to fill the spray tank.

References

Crafts, Alden S. Modern weed control. Berkeley, Calif: University of California Press; 1975. 440 pp.

Klingman, Glenn C.; Ashton, Floyd M. Weed science: principle and practices. New York: John Wiley and Sons; 1975. 431 pp.

Structural Range Improvements

Billy H. Hardman, *Chairman*

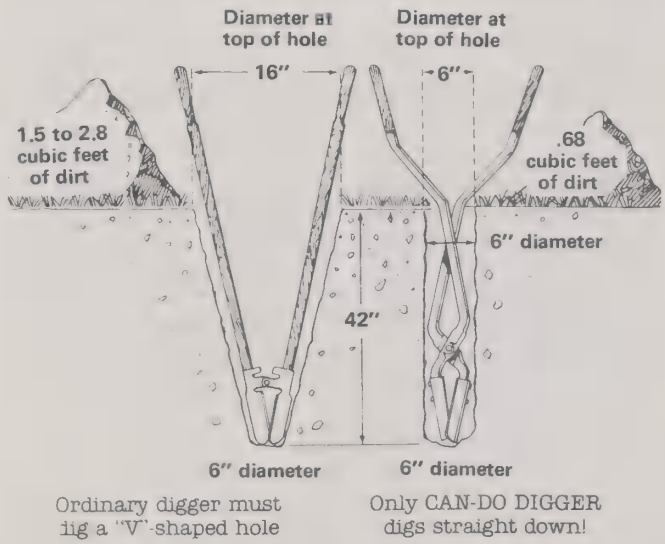
Activities

Two reports the workgroup has assisted with and reviewed are:

- *Rangeland Fencing Systems–State-of-the-Art Review*
- *Preventing Livestock Water from Freezing*

These reports have been prepared by SDEDC and are now in the final stages of completion.

This year, the workgroup has field tested a new type of post hole digger called a Can-Do Digger. With this new post hole digger a post hole can be dug 42-inches deep with only a 6 inch diameter from the top down. This is made possible by the double crossover design of the handles. The cost is about $75. The digger is manufactured and marketed by Can-Do Diggers, Inc., 750 North Milford Rd., Highland, MI 48031, (313) 887-7454.



Comparing standard post hole digger with new type.

Boom for Pneumatic Fence Post Driver

By James A. Young, Richard Madril, and Victor Rashelof, Agricultural Research Service, Reno, Nev.

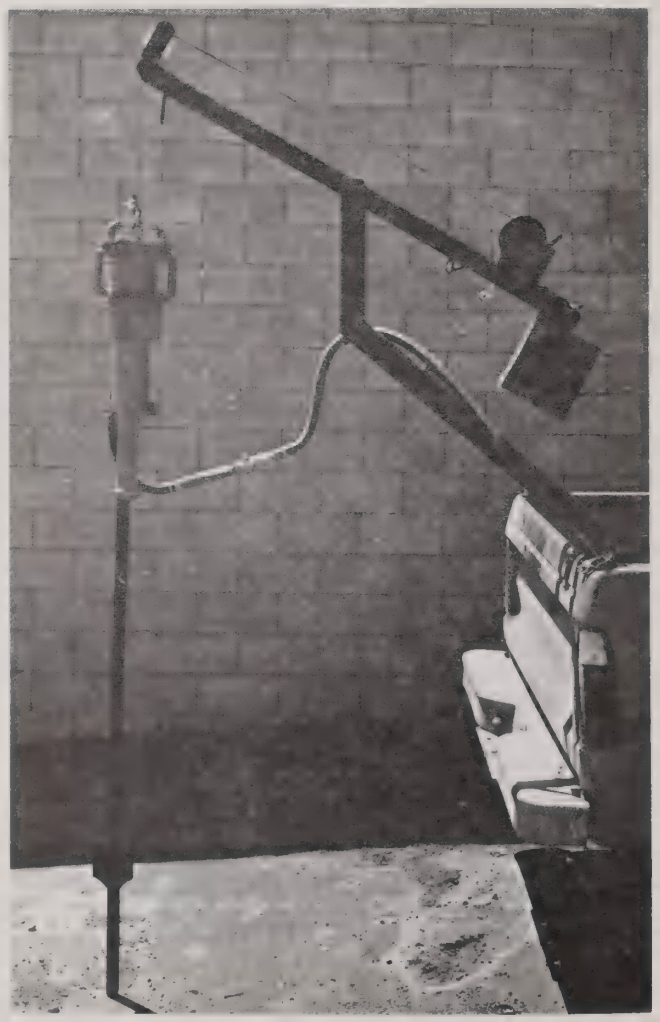
The pneumatic post driver as described in the *Revegetation Equipment Catalog*[1] is a very useful tool for driving steel fence posts. The weight of the driver, 65 pounds, makes it very tiresome and difficult for single operators to handle. To make the driver more convenient for one operator we designed a counterbalanced boom to suspend the driver at the correct height for driving posts.

Boom Design

The counterbalance boom was designed to mount in boots used on the bed of trucks for mounting booms with hand winches. These boots have 3.5-inch-diameter openings with a machined bearing and are 12.25 inches deep.

The boom was designed with a curved mast so the arc of the swing of the counterbalance was reduced. This reduced arc is a safety factor, plus it allows the boom and a 12-horsepower air compressor to fit in the back of a short-wheelbase pickup.

The first counterbalance boom that we designed had a slotted chain keeper mounted on the end of the boom. A chain was used to hang the post driver from this keeper. As a boom is moved from truck to truck with different height beds or different length posts are driven, the height of the driver can be adjusted by slipping the chain through the keeper. The only moving part on this boom is the shaft that provides the fulcrum for the boom.



Modified boom.

[1] Larson, J.E. 1980. Revegetation Equipment Catalog. Prepared for the Vegetation Rehabilitation and Equipment Workshop (VREW). USDA For. Serv. Equipment Development Center, Missoula, MT. 167 pp.

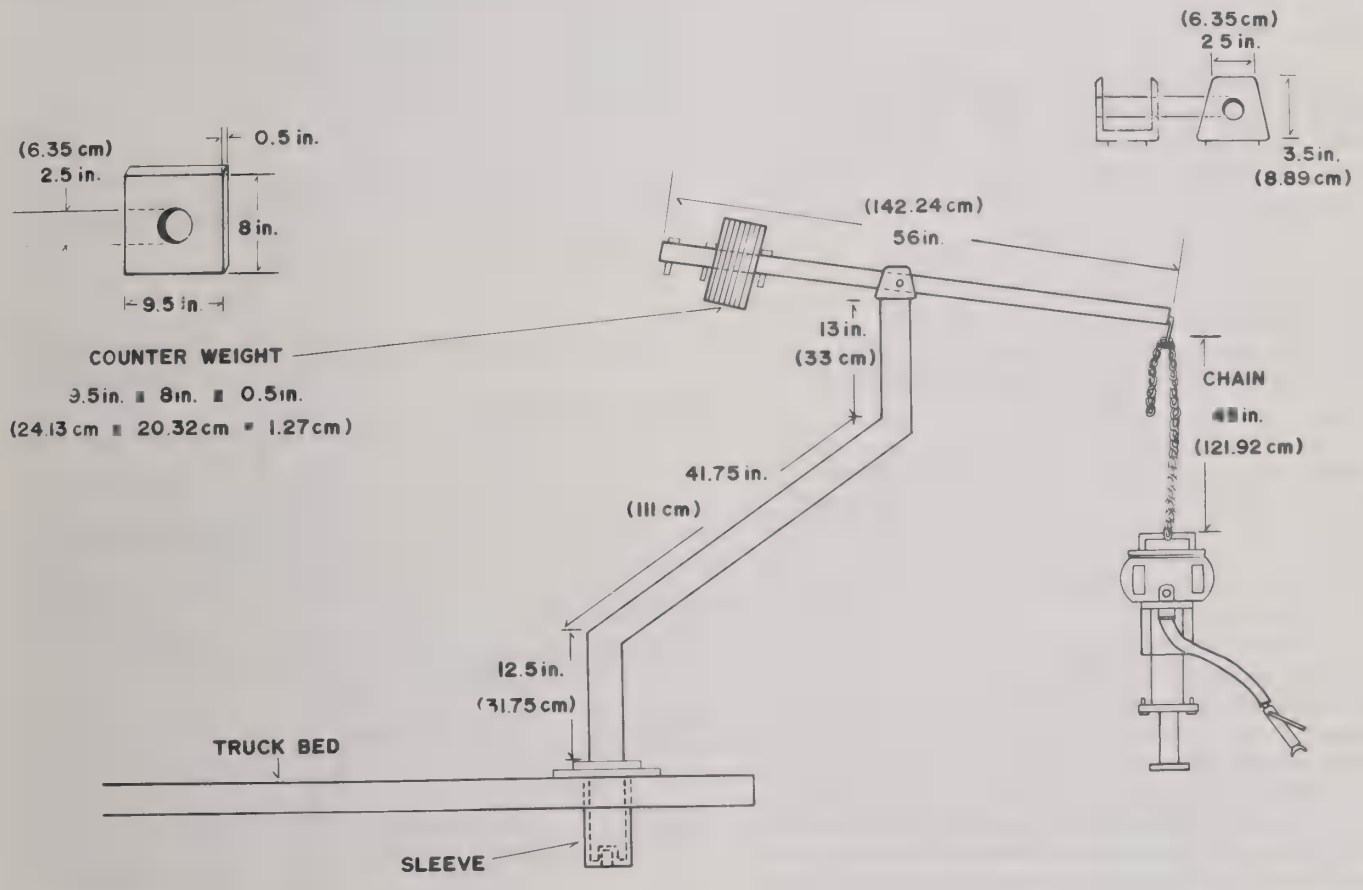
Cost and Performance
Total cost of this boom is $300, excluding the cost of the boot. We tested this boom on a very rocky site driving 6-foot posts. With a three-person crew (truck driver, driver operator, and post distributor) it was easy to drive more than one post per minute, including moving time between posts.

The only problem we encountered was attaching the driver to the boom. The hammer is heavy and a second person had to feed the chain through the keeper while one person lifted the driver. In addition, a third person was required to lift the counterbalance weights.

Second Model
The boom was redesigned with a hand winch located on the butt of the boom and a pulley at the tip. Aircraft cable is attached to the winch and threaded through the pulley. The end of the cable is attached with a U clamp to the driver.

A short length chain and a hook welded to the mast make it possible to convert the counterbalance boom into a rigid lifting boom. The driver can be easily lifted into place with the ratchet winch. The winch and cable provide infinite adjustments for height. A chain is loosely attached from the driver to the original keeper on the boom as a safety measure. This model of the boom does not materially speed up operation of the boom and driver but makes easier the attaching of the driver to the boom.

The relatively inexpensive counterbalance boom greatly enhances the usefulness of the pneumatic post driver. Use of the modified boom makes the driver a one-person tool.



Boom for pneumatic post driver.

High Performance, Counterbalanced Wind Machine Development

By Floyd C. Sutz, Executive Vice President,
Wind Baron Corp., Phoenix, Ariz.

After 5 years of extensive research, development, and testing, a high performance water pumping wind machine that begins operation in winds of only 3 to 5 mph is now available from Wind Baron Corp.

The Wind Baron, 21-foot-diameter, Mark IV Wind Machine incorporates a patented counterbalancing system that eliminates 100 percent of the sucker rod weight and 50 percent of the water column weight, allowing operation in light winds. Additionally, it has sensitive wind "tracking" features that further enhance its performance.

In a 7-month, side-by-side test certified by Texas A&M University a Wind Baron wind machine delivered over 13 times more water than a conventional windmill in winds below 10 mph, and over 32 percent more in winds above 10 mph.

Wind Baron performance charts show the Mark IV will deliver 3,000 gallons per day from a 500-foot depth, with a 5-mph wind. It will lift 18,000 gallons per day from this depth in a 20-mph wind. At shallower depths, the machine is capable of providing over 375,000 gallons per day for irrigation.

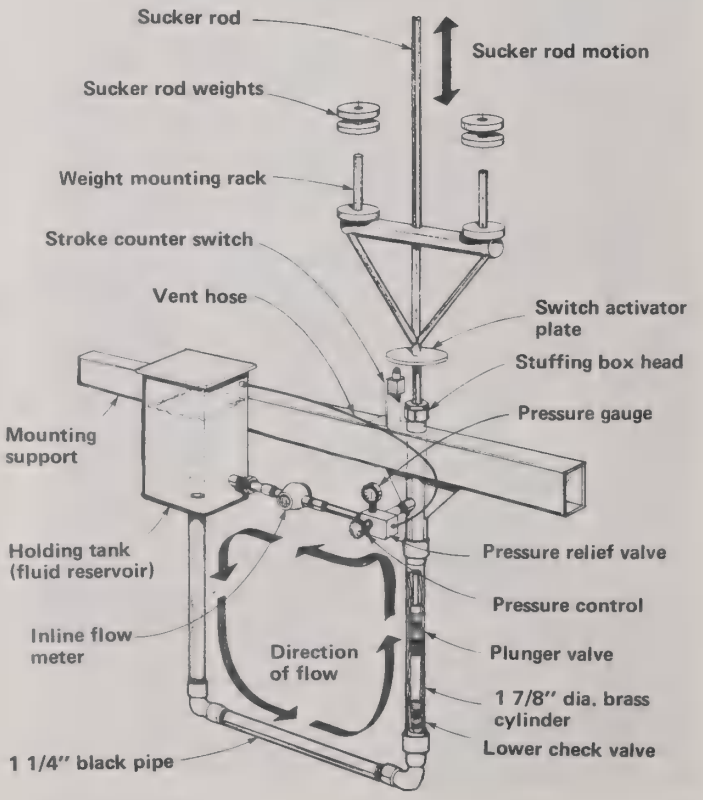
Wind Baron has designed the Mark IV for long life and low maintenance, in addition to low wind requirements. It is completely hot-dip galvanized after fabrication, and uses a transmission and bearings made by Borg-Warner. The only recommended maintenance is an annual oil change and lubrication.

To assist user evaluation, Wind Baron has proposed the establishment of industry standards to measure and specify water pumping windmill performance. In this manner, users will be able to predict, with certainty, the amount of water a windmill will deliver from a specified depth, in a given wind speed, over a set time period.

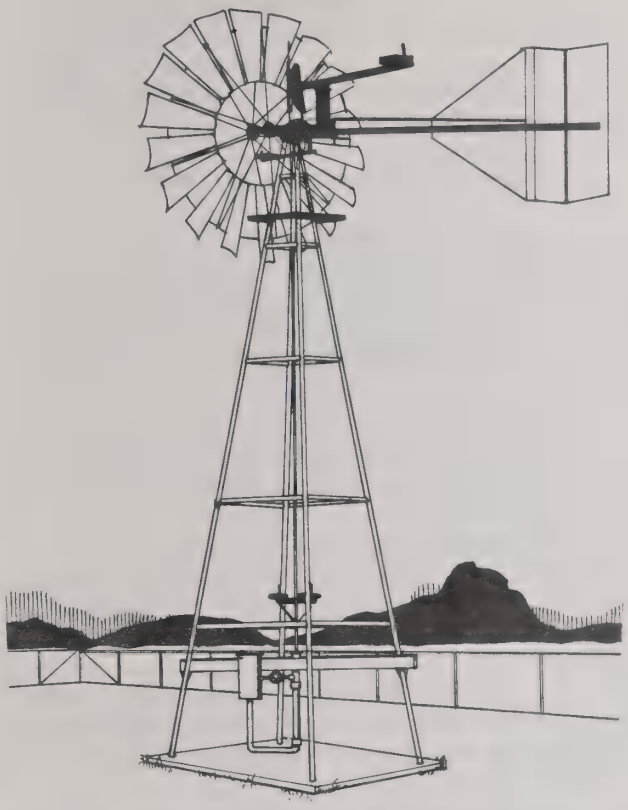
Wind Baron has gathered extensive performance data over the past 3 years through sophisticated testing techniques, and has developed several well simulators to assist in performance testing. With the use of these well simulators, any reasonable well depth can be simulated, allowing windmill performance testing at various simulated water depths without the need for a well. The company will readily make this technology available to other wind system manufacturers and outside parties interested in its use.

For further information, contact Wind Baron Corp., 3702 West Lower Buckeye Rd., Phoenix, AZ 85009, (602) 269-6900.

Wind Baron Mark IV Wind Machine. The walking beam counterbalance and aerodynamic tail are major factors in the Mark IV's ability to operate at low windspeeds. In periods without wind, an internal combustion engine, solar, or other power source can operate the Mark IV. Included as standard equipment is a separate power takeoff shaft, which can drive an electrical generator or other equipment.



Well Simulator. Developed by Wind Baron Corp. for wind machine performance testing. Sucker rod weight is simulated by placing weights on the mounting rack attached to the sucker rod. A standard pump cylinder forces water through an adjustable pressure relief valve during the lift stroke to simulate water load. By adding weights and adjusting the pressure relief valve, any reasonable well depth can be simulated.



Well simulator in place on a windmill. With the well simulator, windmill performance testing at various simulated water depths can be accomplished.

Range Water Systems Improvements Project ED&T 0E01D40

By Dan W. McKenzie, Forest Service, San Dimas, Calif.

The goals of this project are to improve range water supplies and systems for pumping and handling range water. The objectives, as determined by the Structural Range Improvements Workgroup, are to: (1) Investigate and develop systems for inhibiting or preventing stock watering tanks from freezing; (2) investigate and develop solar water pumping systems as alternatives to the conventional windmill.

The Range Water Systems Improvements project is very timely because of the amount of research and development work in water pumping and the new equipment and techniques becoming available. Some of the new equipment, under some circumstances, has the potential to be cost-effective alternatives to the conventional windmill.

Preventing Stock Water Tanks from Freezing

The San Dimas Equipment Development Center has investigated methods and techniques to keep livestock water tanks from icing over and preventing animals from drinking. The Center has prepared a report on this investigation that is in the final stages of completion. (For more details on some of these methods and techniques, see VREW 35th annual report, Tulsa, Okla., February 8 and 9, 1981.)

Solar Water Pumping Systems

Three categories of equipment may offer alternatives to the conventional windmill: (1) photovoltaic-powered pumping systems, (2) solar-thermal pumping systems, (3) improved or new windmills. In the photovoltaic and improved and new windmill categories, considerable research and development are underway with promising new equipment being developed. In the solar-thermal category, demonstration equipment is still being operated, but little, if any, new equipment is being produced.

Photovoltaic Pumping Systems

The World Bank continued its solar water-pumping project by purchasing and testing 12 additional solar water-pumping systems. A report is expected to be available in September 1983.

The Solar Energy Research Institute, 1617 Cole Blvd., Golden, CO 80401, has published a report, *Evaluation of Pumps and Motors for Photovoltaic Water Pumping Systems*, by David Waddington and A. Herievich, describing tests conducted on pumps powered by photovoltaic cells. This is a very good basic report on powering and operating pumps with photovoltaic cells. Copies are available from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22161. The cost is $3 for microfiche and $5.25 for printed copy.

In addition to the unit described in last year's VREW report, several other companies have reported supplying maximum power controller systems (MPCS). A MPCS will take the low amperage and constant voltage output of photovoltaic modules just after sunrise and convert it to high amperage (enough to start and run the pump) and lower voltage (pump will run slow). As the day progresses, the photovoltaic modules will produce higher amperage and the constant voltage. Then the maximum power controller amperage output will remain constant with the voltage output increasing. This will result in a faster running motor and more water pumped.

Photovoltaic-Powered Pumping System with Submersible Pump

Two manufacturers now have available water pumping systems using submersible pumps that can be powered by solar cells and require no batteries. One uses dc and the other an ac submersible pump. The dc submersible pump is powered directly by the dc current from the solar cells. To power the ac submersible pump, a dc-to-ac inverter must be used. The dc-to-ac inverter used inverts the dc current to varying frequency, 3-phase ac current that powers a 3-phase ac motor at varying speeds. The dc submersible pump unit is available from Jacuzzi, P.O. Box 3533, Little Rock, AR 72203, (501) 455-1234. The ac submersible pump unit is available from Grundfos, 2555 Clovis Ave., Clovis, CA 93612, (209) 299-9741.

Series-Parallel Photovoltaic Panel Switching
In a series-parallel photovoltaic panel switching system, panels are divided into two equal sets. Within each set, the panels are connected in series and then each set is connected to a switching unit that will either connect the two series-wired sets of panels in parallel for combined amperage output, or in series for combined voltage output. During times of low solar radiation, such as early morning or during cloud cover, the switching unit will connect the sets of panels in parallel, resulting in a high amperage and low voltage output that will start or keep the motor running, but at half speed. Series-parallel photovoltaic panel switching devices for operating water pumps are being marketed by GPL Industries, P.O. Box 306, La Canada, CA 91011, (213) 790-0762.

Production model of new type pump jack, powered by series-parallel photovoltaic panel switching.

Improved or New Windmills
Work continues on developing new windmills or improving conventional models. Improvements under development include:

- Fully counterbalanced windmill.
- Cam-operated windmill.
- Automatic stroke control for a conventional windmill.
- Automatic stroke control for a three-bladed wind turbine.
- Hydraulic system that replaces the pump rods of a conventional windmill.
- Electric wind generator driving an ac submersible pump.

Fully Counterbalanced Windmill
Production models are now available. In a fully counterbalanced windmill, one-half the pumping work is done on the upstroke and one-half on the downstroke. On an unbalanced windmill, all the pumping work is done on the upstroke.

Fully counterbalancing a windmill allows the windmill to start and pump water at lower windspeeds than a windmill that is not counterbalanced. When a windmill is fully counterbalanced, all the weight of the pump rods and half the weight of the water column, plus one-half the pump friction force, are cancelled. This results in the overall starting torque being reduced to about 33 percent (pump mechanical efficiency 70 percent which may be high) as compared to an uncounterbalanced windmill. As the torque developed by a windmill is about proportional to the square of the windspeed and if a fully counterbalanced windmill will start in a 7-mph wind, a 12.2 mph wind would be required to start an uncounterbalanced windmill.

Through extensive testing on the Navajo Indian Reservation near Window Rock, Ariz., it was determined that a fully counterbalanced windmill will pump substantially more water (13.46 times) at windspeeds below 10 mph than a conventional windmill; and at windspeeds above 10 mph, 32 percent more water was pumped. This windmill, which can be fully counterbalanced, is available in a 21-foot size only, from the Wind Baron Corp., 3702 West Lower Buckeye Rd., Phoenix, AZ 85009, (602) 269-6900.

Cam-Operated Windmill
Development of a cam-operated water-pumping windmill has been completed and manufacturing and marketing efforts are underway. In this cam-operated windmill, three-quarters of the pumping cycle is used for lifting the sucker rods and only one-quarter for return. The cam mechanism reduces the starting torque required to less than half that of a conventional windmill. This allows the windmill to start and pump water at lower windspeeds than a conventional windmill. Limited production models have been produced. For more information on this windmill, contact Wind Energy Unlimited, Inc., 2527 North Carson St., Suite 205, Carson City, NV 89701, (702) 883-9303 or (805) 248-6023.

Automatic Stroke Control for Conventional Windmills
Mechanical Engineering Professor Emeritus Don Avery of the University of Hawaii has developed and validated an automatic stroke control device for use with a conventional windmill. This device automatically changes the stroke of the well cylinder to match the level of energy in the wind (the length of the pump stroke is changed proportional to windspeed squared). This results in the volume of water pumped in relation to windspeed following the same cubic

relationship of windspeed to the level of energy in the wind. If the windspeed doubles, eight times more water will be pumped. The device will vary the stroke from 3 to 16 inches. Discussions are under way for the manufacture of the device as a kit for the conventional windmill. For more information, contact Don Avery, 45-437 Akimala St., Kaneohe, HI 96744, (808) 247-1909.

Automatic Stroke Control for a Three-Bladed Wind Turbine
Professor Avery is also developing an automatic stroke control device for a three-bladed electric generating type wind turbine. The development model will use a 23-foot-diameter rotor and the stroke will vary from zero to 27 inches. The advantage of this device over the device developed for the conventional windmill is that a more efficient and less costly wind turbine can be used because the stroke will go to zero allowing the three-bladed wind turbine to start.

Hydraulic System to Replace Pumping Rods
A firm in Texas is developing a hydraulic system to replace the pumping rods of a conventional windmill. The windmill is connected to a well-type cylinder located at ground level. The output of this well cylinder (water under pressure) is pumped down the well to operate a cylinder pump. The advantages, are that it is light weight and can be quickly removed from a normal depth well by hand and the unit will start and pump water in light winds. This is because the windmill starting-torque requirement is much lower as it does not have to lift the weight of the sucker rods on the first stroke. For more information, contact W.L. Hydraulics, 10203 Kotzebue, Suite 106, San Antonio, TX, 78217, (512) 654-1412.

Electric Wind Generator Driving an AC Submersible Pump
The USDA-ARS at the Conservation and Production Research Laboratory, Bushland, Tex., is investigating the coupling of an ac submersible centrifugal pump directly to an ac wind generator to operate as a stand-alone water pumping system. Laboratory tests show the system to be very promising. The advantages would be lower initial cost and reduced maintenance. The reason for the potential for lower initial cost is the electric wind generator is lighter, smaller, and made with fewer parts than the multiblade farm-type windmill (conventional windmill). The reasons the two- or three-blade wind turbine can be made smaller is it operates at a higher efficiency than a multiblade farm-type windmill (about 30 percent for the multiblade and 40 to 45 percent for the two- and three-blade wind turbine). Also, the pump system used with the wind turbine can extract more power from the wind turbine than the pump system used with the multiblade windmill. This is because the submersible centrifugal pump, unlike the conventional positive displacement windmill pump, which can only draw power directly proportional to windspeed, can draw power more closely to the cube of the windspeed. The system should require less maintenance because of the use of a down hole, submersible pump in place of conventional pump rods and well cylinder. Equipment to assemble an electric wind generator driving an ac submersible pump is commercially available.

Useful Publications on Water Well Systems
The Missouri Water Well and Pump Contractors Association, Inc., publishes a very good *Water Well Handbook*. The source and cost of this handbook and other water well system publications are listed below:

Planning for an Individual Water System $6.95

American Association for Vocational
Instructional Materials (AAVIM)
Engineering Center
Athens, GA 30602

Private Water Systems Handbook $2.50

Midwest Plan Service
Iowa State University
Ames, IA 50011

Water Systems Basics $3.00

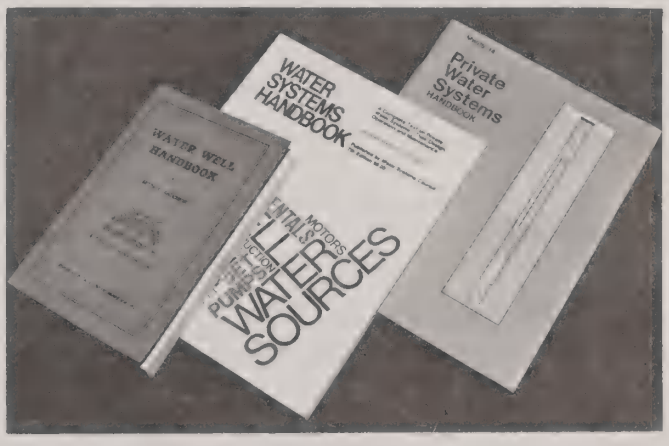
DE/Journal
522 North State Rd.
Briarcliff Manor, NY 10510

Water Systems Handbook (7th edition) $6.00

Water Systems Council
221 North La Salle St.
Chicago, IL 60601

Water Well Handbook $10.00

Missouri Water Well and Pump Contractors
Association, Inc.
P.O. Box 517
Belle, MO 65013



Useful publications on water well systems.

Accomplishments of the VREW—History

Richard Hallman, *Forest Service, Missoula, Mont.*

Introduction

VREW's roots go back to World War II, when more wool and beef were needed to sustain the war effort. With increased demand for sheep and cattle, officials sought to increase productivity from National Forest rangelands. However, many of these lands, already suffering from a long history of abuse, could not support additional livestock without substantial improvement. Range seeding had been demonstrated by small-scale tests in the 1930's, but additional research was necessary to implement large-scale seeding efforts. The research was approved and seeding tests were initiated throughout the West.

The range seeding test program proved successful, but several problems needed to be solved before it could be effectively expanded. A major problem was that the equipment commercially available at that time was designed for crop production on farmland and was poorly adapted to the rough terrain, rocky ground, steep slopes, and dense brush encountered on rangeland.

A conference of Forest Service researchers and administrators was held in 1945 to discuss the state-of-the-art in range seeding and what needed to be done. Participants at the conference recognized that a major effort was needed to test, adapt, or develop suitable equipment for range seeding and other improvements. An interregional administrative research committee was established to work with the staff at the Forest Service Equipment Development Center at Portland, Oreg. Center personnel joined the group to add their expertise to help solve rangeland equipment problems. The Center also provided the necessary facilities and equipment for the development efforts. Eventually this work was moved to the Center at Arcadia, Calif. In the late sixties some Range equipment development work was started at MEDC.

The conference group became known as the Reseeding Equipment Development Committee. In 1958, it changed its name to the Range Seeding Equipment Committee, and, later, became VREW. The first formal committee meeting was held in Portland on Dec. 9-11, 1946.

The first few annual committee meetings were attended exclusively by Forest Service personnel from various Regions and Stations. After the American Society for Range Management (later the Society for Range Management) was founded in 1948, the Range Seeding Equipment Committee met at the same time to encourage attendance at both meetings.

Other agencies soon became interested in the Range Seeding Equipment Committee. Representatives of the BLM and SCS attended the committee meeting at Denver, Colo., in January 1949. A great deal of controversy existed at that meeting concerning the name and purpose of the committee. The debate resulted in a better understanding of the committee charter. Later that year the committee objectives were expanded to: "1) Evaluate available equipment suitable for range seeding (and brush control) and if none is satisfactory, suitable equipment (shall) be designed, constructed, and tested under guidance of the committee; 2) Prescribe specifications and standards for purchase, maintenance, and use of equipment and materials; 3) Function as a clearinghouse for . . . information, and 4) Act in an advisory capacity . . . in range seeding and undesirable plant control policies and procedures."

At times, the survival of the Range Seeding Equipment Committee seemed doubtful. Attendance at most of the early meetings was low. However, the enthusiasm and dedication of committee members attracted other land managers facing similar equipment difficulties. As committee efforts expanded several other agencies became involved in committee meetings and activities. In 1951, BLM first contributed funds for committee projects. The BIA and SCS added financial support in 1955 and 1956, respectively. Interagency participation and funding has helped insure the survival and success of the Range Seeding Equipment Committee and VREW.

During the 1955 meeting, the committee decided to function as an informal organization without restricting membership or participation by interested agencies or individuals. This structure has encouraged participation from groups with diverse interests and has promoted a free exchange of information. Over the years, many Federal and State agencies, universities, and firms have cooperated with the committee, and VREW, by contributing funds for special projects, participating in field operations and evaluations, or supplying materials and equipment for testing.

The informal structure and extensive cooperation have helped VREW accomplish its stated goals.

The Vegetative Rehabilitation and Equipment Workshop, VREW, is a forum to provide exchange of ideas to enhance the development and dissemination of technology used in improving rangelands and surface-mined spoils. To better identify an equipment development project, VREW may:

1. Promote an understanding of the ecology of the land to be treated as a first step in modifying or designing new equipment.

2. Utilize cost efficiency in evaluating proposed projects for selection.

3. Improve equipment evaluation through consultation with interested or affected Federal, State, and private organizations, and individuals.

The Range Seeding Equipment Committee formally changed its name to Vegetative Rehabilitation and Equipment Workshop (VREW) in 1974 to better reflect the diversity and broadened scope of its support and interest. Today, most Federal and several State land management agencies are represented in VREW. In addition, universities and industries are becoming increasingly involved.

The work of the VREW can be broadly divided into four categories: (1) plant control; (2) ground preparation; (3) seeding and planting; and (4) publications. Some VREW accomplishments in the four areas follow:

Plant Control

Anchor Chains, Projects 602 and 1790. The objectives of these two projects were similar. The initial effort (Project 602) evaluated combinations of cables and light chains. Chaining in opposite directions with a single 40-pound link chain resulted in more satisfactory juniper control than did a single pass using two chains of different lengths. Renewed interest in brush chaining in 1966 followed a relatively inactive period.

Project 1790 was a continuing effort to improve the effectiveness of chaining for controlling woody vegetation. Smooth chains were effective for seed covering and browse rejuvenation. Tests indicated that heavier chains were more effective for brush control than lighter chains, but required more power to pull. Chains weighing from 20 to 110 pounds per link are available from U.S. Navy surplus. Chains weighing over 70 pounds per link are generally recommended.

The Ely chain developed by the BLM in Ely, Nev., and the Dixie Sager developed by the Forest Service, Dixie National Forest, Utah, are modified with steel bars or sections of railroad iron welded to the links. This increases the uprooting and scarifying action of chains as they roll over the ground. The Ely chain has an 18-inch bar or rail section welded across every link or every third link. The Dixie Sager has 8-inch sections of railroad iron welded to both sides of each link. The rails or bars are hard-surfaced to reduce wear.

Drawings of chains are available from MEDC. A handbook on chaining, *The Ely Chain*, was also prepared.

Project approved and initiated	1957
Project reviewed annually	1957-1971
Project terminated	1971
Project accomplished by Bureau of Indian Affairs, Bureau of Land Management, Soil Conservation Service, and Forest Service (Missoula and San Dimas Equipment Development Centers)	

The Dixie Sager.

The Ely chain.

Ground Preparation

Brushland Plow, Project 328. The objective of this effort was to design a rugged plow, patterned after the Australian "Stump Jump Plow," for use on rangelands.

Results of this effort produced a most durable and effective plow for wildland situations. The lengthy project history involved a number of test periods of 2 or more years to determine the adequacy of the unit's components and need for improvement. The unit weighs approximately 6,000 pounds and plows a 10-foot swath. With reasonable care, it can be used effectively in extreme situations without excessive breakage or wear. Its conformation and weight present transportation difficulties. The brushland plow is available commercially. Drawings and a service and parts manual are available from SDEDC.

Project approved and initiated	1949
Project completed	1964
Project review (various modifications, updating of specifications and drawings, etc.)	Periodically during 1949-1968
Project accomplished by the Bureau of Land Management, and Forest Service (San Dimas Equipment Development Center)	

Brushland plow.

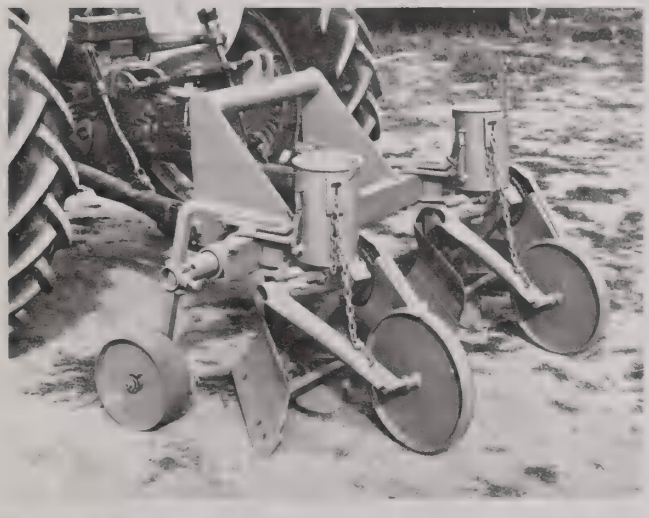
Seeding and Planting

Browse Seeder, Project 502. The purpose of the project was the development of an appropriate means of seeding browse, forbs, and grasses for wildlife habitat improvement.

A satisfactory seeder was developed in cooperation with the Walter Hansen Machine Co. The unit was designed for use with 3-point hitch farm tractors. A drawbar for crawler tractors was developed by the Bureau of Land Management to allow mounting two or more units. Herbaceous competition is removed by a scalper. A metering device accommodates browse, forb, grass, and tree seed of most sizes and mixtures. The seeder is capable of operating under a wide variety of conditions, including very rocky sites. The seeder has been effective for both interseeding and controlling erosion.

Drawings are available from SDEDC.

Project approved and initiated	1956
Project reviewed annually	1956-1974
Project completed	1968
Project terminated	1974
Project accomplished by the Forest Service (Intermountain and Pacific Southwest Regions, Intermountain Experiment Station, and San Dimas Equipment Development Center), California Department of Fish and Game, Idaho Fish and Game Department, and Utah Division of Wildlife Resources	

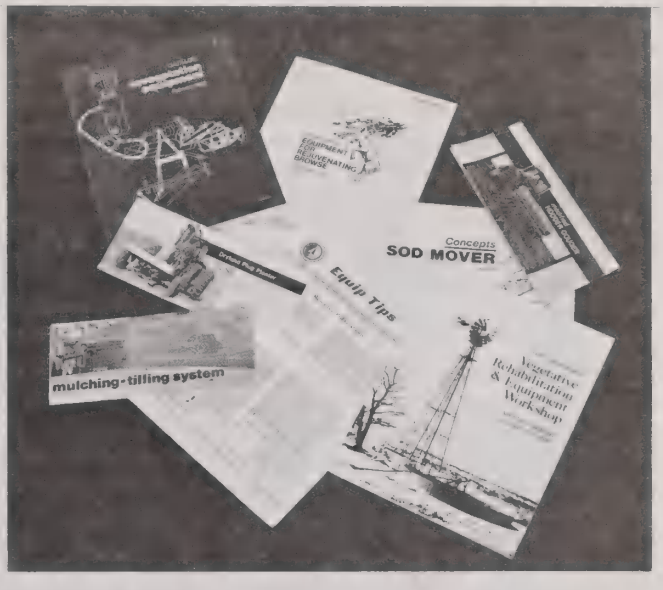


Hanson Browse Seeder.

Publications

VREW is increasing the effort to provide land managers with pertinent, up-to-date information. Much of this information is published in news letters, Equip Tips, Project Records, VREW annual reports, service and parts manuals, operations handbooks, and the *Catalog—Revegetation Equipment*. These publications should help land managers make informed choices about available equipment and techniques for their specific needs.

A growing emphasis is also being placed on collecting and distributing current information about equipment and techniques for rangeland improvement and disturbed land revegetation. The Range Seeding Equipment Committee has supplied several useful publications, including the *Range Seeding Equipment Handbook, Chemical Control of Range Weeds, Operating Hints for Equipment Used in Range Revegetation,* and others.



Range publications.

Accomplishments of VREW—Development Life of the Rangeland Drill

Dan W. McKenzie, *Forest Service, San Dimas, Calif.*

The rangeland drill is VREW's most successful project. It has been used for over 30 years in the rangelands of the Western United States and in several foreign countries. In recent years, the rangeland drill has also been used extensively for strip mine reclamation. Over 325 units have been built.

Like most successful equipment, the rangeland drill progressed through four phases:

- Conceptual.
- Demonstration and validation.
- Full-scale engineering development.
- Production, use, and product improvement.

The conceptual phase of rangeland drill development was carried out by the Range Seeding Equipment Committee when it searched for and tried existing equipment and investigated new concepts.

The demonstration and validation phase was carried out by the Fremont National Forest, which built a unit and did useful work with it.

The full-scale engineering phase was carried out by the San Dimas Equipment Development Center (then at Arcadia, Calif.), which designed and fabricated a prototype rangeland drill for field testing and completed a technical data package that could be used to procure rangeland drills. This work was supported and directed by the Range Seeding Equipment Committee.

The production, use, and product improvement phase was carried out by private enterprise, which fabricated rangeland drills under contract. The use portion was carried out by the Forest Service, Bureau of Land Management, Bureau of Indian Affairs, Soil Conservation Service, States, and private firms. The project improvement part has been carried out by the San Dimas Equipment Development Center, the equipment fabrication contractors, and the user.

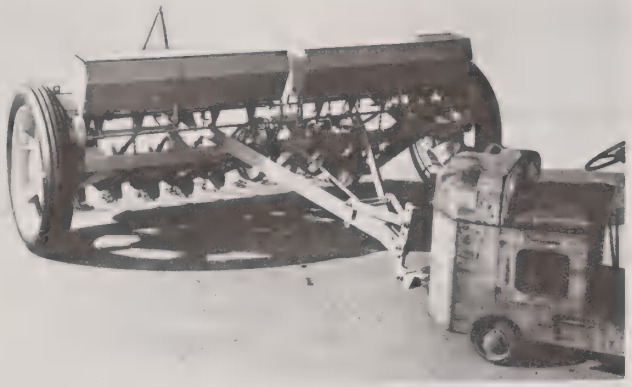
The rangeland drill is an interesting story because of the number of different organizations participating in the development at the time and stage where their unique capabilities were needed and the Range Seeding Equipment Committee (now, of course, VREW) serving as a link to the next phase. With the responsibility of the production of rangeland drills being passed to private enterprise, the development of the drill serves as an excellent example of the cooperation between Government and private enterprise (see table).

Development Life of the Rangeland Drill

Conceptual Phase	
1946-1950	Range Seeding Equipment Committee tested farm equipment and considered concepts.
Demonstration and Validation Phase	
1951	John Kucera, Fremont National Forest, designed and built demonstration model and field tested unit, validating design.
Full-Scale Engineering Development Phase	
June 1951	Tom Coldwell, Forest Service, Arcadia Equipment Development Center (AEDC), visited Fremont National Forest to investigate Kucera's demonstration model.
Jan. 1952	Fremont National Forest drill shipped to AEDC for study. John Kucera visited Arcadia.
Jan. 1952	Range Seeding Equipment Committee reviewed alternative for rangeland drill. Decided drill should be 10 feet wide with single seedbox like the Fremont drill.
Oct. 1952	Prototype drill completed by AEDC.
Oct. 1952	Prototype drill tested on the Fremont National Forest and Utah.
1953	Field testing of prototype drill in New Mexico, Arizona, and California.
May 1954	Technical data package (drawings and specification) completed and furnished to contracting by AEDC.
Production, Use, and Product Improvement Phase	
April 1955	First production drill completed by Laird Welding and Manufacturing Works, Merced, Calif., and shipped to Forest Service, Reno, Nev.
1959	Work done by Forest Service in Washington and Oregon on deep furrowing arms.
1960	A hinged fold over drawbar and acreage meter added; part stockage for rangeland drill and brushland plow established at Forest Service Equipment Depot, Stockton, Calif. John Deere discontinued production of B 20 x 6 grain box; grain box replaced on rangeland drill by John Deere Model PD 10 x 6; fertilizer and grass seed attachments now also available.
1964	Parts manual completed, printed, and distributed.
1966	Hinged-type drawbar and parking stand designed, and operator's, service, and parts manual completed.
1967	Hinged drawbar and parking stand successfully field tested.

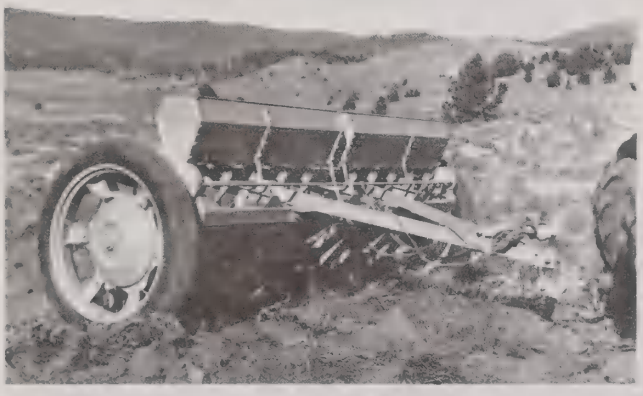
1968	John Deere discontinued production of PD 10 x 6 grain box; John Deere B 206 B grain box selected for replacement. New drawings completed for drill.
1969	Two experimental deep furrowing arms field tested by BLM, Elko, Nev.
1970	Six redesigned deep furrowing arms fabricated and field tested by BLM, Elko, Nev.
1971	Adjustable deep furrowing arms designed, two fabricated and field tested by BLM, Elko, Nev.
1972	Three production prototype adjustable deep furrowing arms, with design changes, fabricated and successfully field tested, Lincoln National Forest, Alamogordo, N.Mex. Adjustable deep furrowing arms available as option in the technical data package.
1973	Rangeland drills with adjustable deep furrowing arms used to seed 4,100 acres in Idaho and Oregon.
1974	John Deere discontinued B 206 B grain box production. Also, 9.00 x 36 tire no longer available; replaced by 11.25 x 28 tires.
1975	"Rangeland Drill Operations" completed as BLM Technical Note 289. Forest Service Equipment Development Center, San Dimas, Calif., assisted Laird Welding and Manufacturing Works in mounting a John Deere 8250 series grain box on rangeland drill; technical data package not updated.
1976	Seedbox capable of metering trashy seed tested on USDA/ARS Jornada Experimental Range, Las Cruces, N.Mex.
1977	Oilite and steel bushing bearing in opener arms replaced with triple seal, nonlubricating ball bearings, by Laird Welding and Manufacturing Works.
1978	Hydraulic operated opener arms lift attachment designed and available from Laird Welding and Manufacturing Works.

Demonstration model rangeland drill designed and built by John Kucera and N. R. Smith of the Fremont National Forest, Lakeview, Oreg., in operation on Coffee Pot Flat, 1951.

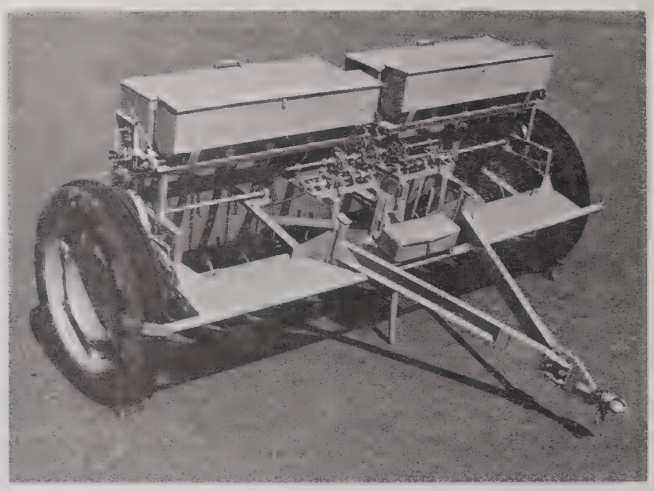


Rollout of full-scale engineering prototype rangeland drill on October 7, 1952, at the Forest Service Equipment Development Center, Arcadia, Calif. Drill is equipped with Model B, John Deere, Van Brunt grain box.

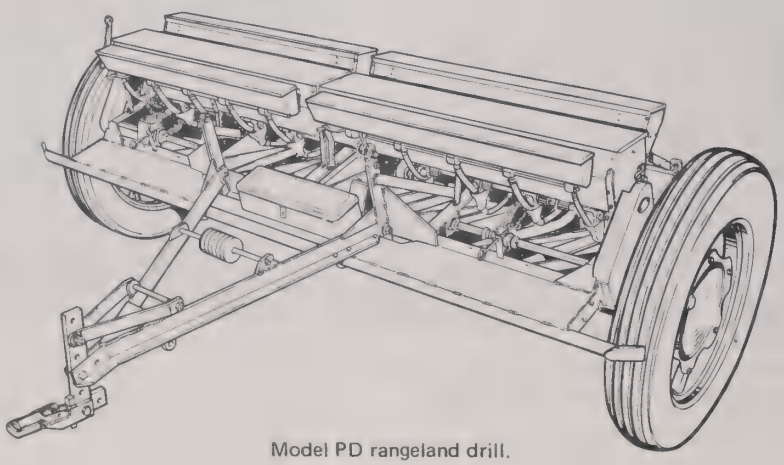
Rangeland drill, 8000 Series, with John Deere 8250 grain box.



Full-scale engineering prototype undergoing operational tests on the Fremont National Forest, October 1952.

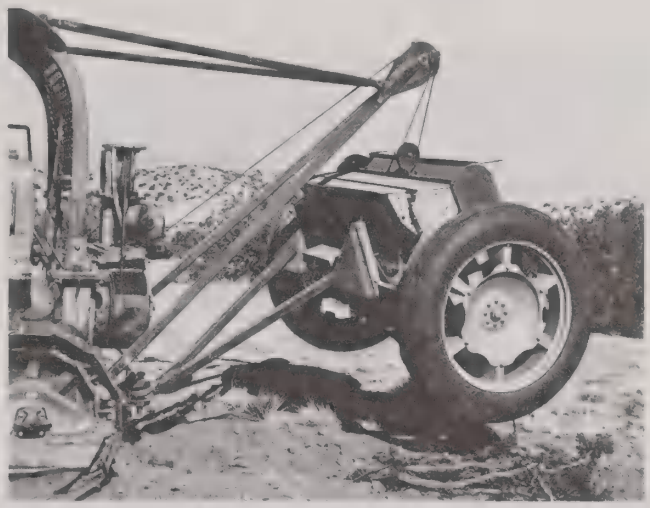


Rangeland drill equipped with seedbox capable of metering trashy seed.



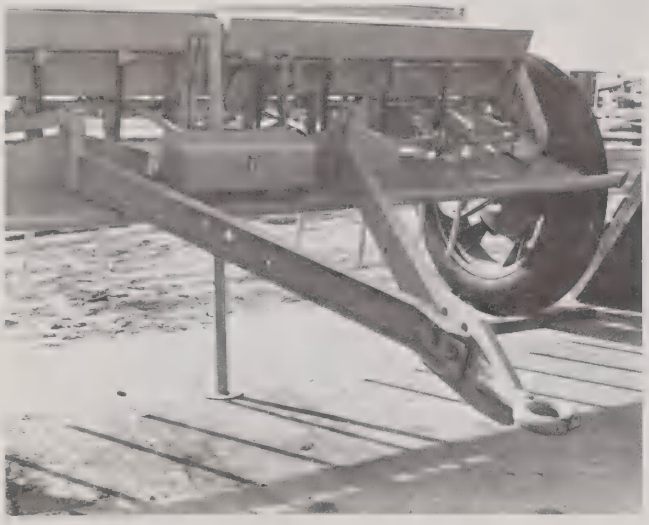
Model PD rangeland drill.

Deep furrowing arm mounted on half-size rangeland drill. Half-size drill is equipped with John Deere PD grain box.



Half-size rangeland drill being carried so the tractor can back up. When the tractor is going forward and the drill is on the ground, the tractor can push juniper and seed in one pass.

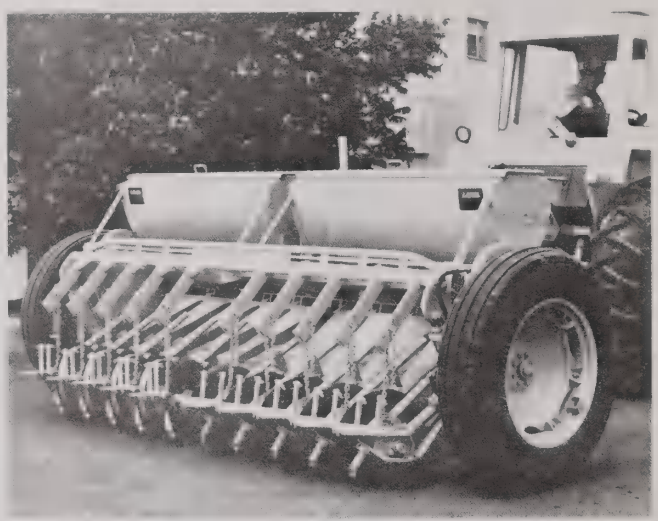
Two-unit hitch for towing rangeland drills equipped with John Deere, Model B, grain boxes.



Hinged folding drawbar.

Hydraulically operated opener arms lift attachment for rangeland drill.

Rangeland drill with stand and hinged drawbar in folded position.



Opener arms in down mode.

Representatives from the Forest Service Equipment Development Centers at San Dimas, Calif., and Missoula, Mont., presented film and slide programs on their current activities of interest not reported elsewhere during the workshop. Ken Dykeman presented the San Dimas program, and Dick Hallman presented the Missoula program.

San Dimas Equipment Development Center

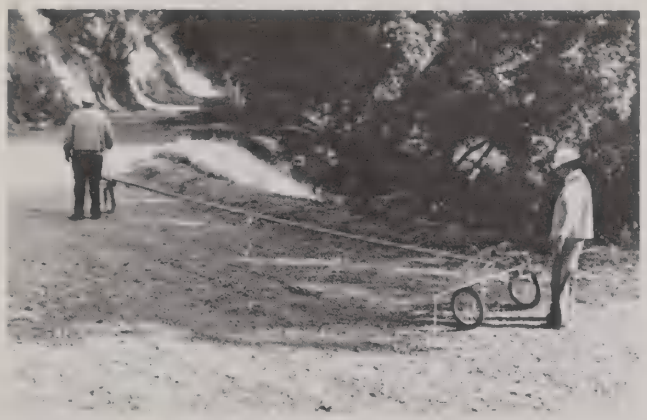
The San Dimas Equipment Development Center (SDEDC) is in San Dimas, Calif., which is about 30 miles east of the greater Los Angeles area. This Center is located in one of the greatest technology areas in the world. About 55 people are employed at the Center, including 15 engineers and a forester. Center personnel are working on about 60 different, but often related, projects. Some projects of interest to workshop participants are described here.

Design Vehicle Simulator

Many present-day forest roads cannot accommodate long-wheelbase vehicles because road curves are too tight. These curves were designed for shorter wheelbase vehicles. When faced with the problem of determining if a long wheelbase vehicle can make all turns of a forest road, a trained observer must first designate where problems may occur. Then, each questionable curve is surveyed and plotted to determine what the vehicle's actual movement on the road would be. This is a tedious and expensive procedure.

Two employees of the Rogue River National Forest, Oreg., conceived an award-winning design of a design vehicle curve-widening simulator, and the San Dimas Center looked at it for possible refinement. Based on input from the Rogue River employees, SDEDC built and field tested an updated version of the simulator. By using this simulator, only those curves that cannot accommodate the simulator need to be surveyed and plotted. The simulator essentially is a tricycle having a long, adjustable wheelbase that produces the movements of a long-wheelbase vehicle.

Engineering drawings and instructions for assembly, disassembly, calibration, and use of this cost-saving device are available from SDEDC.



Design vehicle simulator determines if long-wheelbase vehicles can travel a road and make all turns.

Hopper Hoe

SDEDC was shown a small backhoe, called the Hopper Hoe, that weighs only 1,200 pounds and can be towed by a small pickup truck. The machine is powered by a 5-horsepower gasoline engine. It can be easily transported to the worksite and operated economically (8 hours on 2 gallons of gasoline). The range of buckets and optional extra attachments available increase the utility of this backhoe. Advantages of this small backhoe are that it is economical to operate, and it will do small size, tough jobs that big rigs cannot get in to do. The Hopper Hoe is distributed by Walker-Dee Co., 9237 Butternut, Bakersfield, CA 93306, (805) 366-0143.

Hopper Hoe backhoe.

The Hopper Hoe can be towed behind a small pickup truck or car.

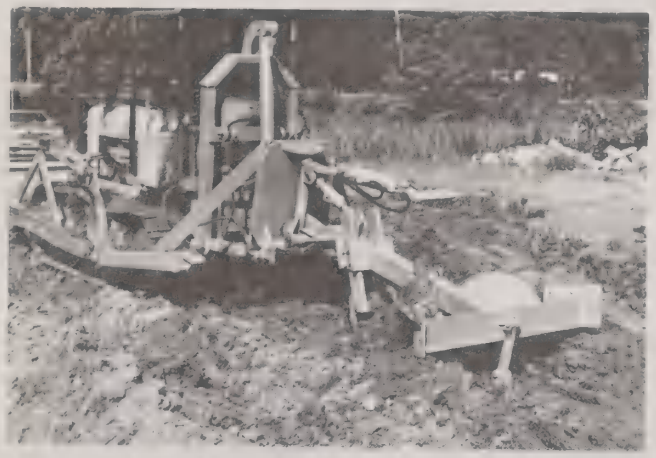
Implement Carrying Hitch

A lift-type hitch has been developed for use with forestry implements such as the rangeland interseeder for rocky and brushy terrain, fireline plows, tree planters, rippers, lift booms, and others.

The hitch provides implement contour-following over typically uneven terrain. The draft angle of the implement may be adjusted on-the-move by the operator. Hydraulic valving provides control of hitch lift, hitch-implement draft angle (pitch), hitch lateral movement (yaw), and a remote cylinder or motor on the implement.

The hitch is particularly useful if a number of implements are to be used with one tractor. Because it incorporates lift, draft (pitch), and lateral movement (yaw) controls, these motions need not be repeated on the implement. Thus, the draft control is eliminated from the fireline plow. The result is less complex and less expensive implements.

The hitch can be built to fit a specific prime mover by Whitfield Forestry Equipment, 6431 Gordon Circle, SW., Mableton, GA 30859, (404) 948-7730.



Implement carrying hitch with a fireplow.

New Brush-Cutting Machines

Woodaxe--This new brush-cutting machine is a combination of a versatile, four-wheel-drive tractor and a vertical-shaft cutting head. It is being marketed by RFD Worldwide, 1301 Huntcliff Way, Clinton, MS 39056, (601) 924-1327.

SHAR "Twenty" Brush Shredder--The SHAR Corp. of Redding, Calif., is marketing a slash treatment and brush shredding machine called the SHAR "Twenty."

Woodaxe.

SHAR "Twenty."

SHAR "Twenty" cutter head: 6-foot disk with cutter teeth.

Substitute Anchors for Cable Transportation Systems
Anchor stump failure is a major concern to cable loggers. Increased anchorage reliability and availability will allow many unharvestable acres to be harvested. This would increase timber supplies. To this end, development of a Substitute Earth Anchor System (SEAS), for use where adequate stumps are not available, and an Early Warning Anchor Failure Detection System (EWAFDS), that will detect and announce impending anchor (stump or substitute anchor) failure, are this project's objectives.

Available anchor systems and development concepts for new anchor systems were the subject of a report furnished by Value Systems Engineering. The report explores the capabilities, limitations, costs, and ancillary equipment characteristics of plate, pickett, screw, grouted, rock bolt, excavation, and propellant imbeddment anchors.

Rockwell International Corp. delivered demonstration-validation EWAFDS hardware. Completion of system accuracy validation and field testing awaits further funding. The system consists of five remote units and a central control unit. Each remote unit is made up of: (1) motion sensors (accelerometer and velocity transducers), (2) strain sensors, (3) signal processing equipment (microprocessor), (4) transmitter/receiver, and (5) battery pack. The central control unit is made up of a transmitter/receiver, microprocessor, tape recorder-printer, and LED display unit.

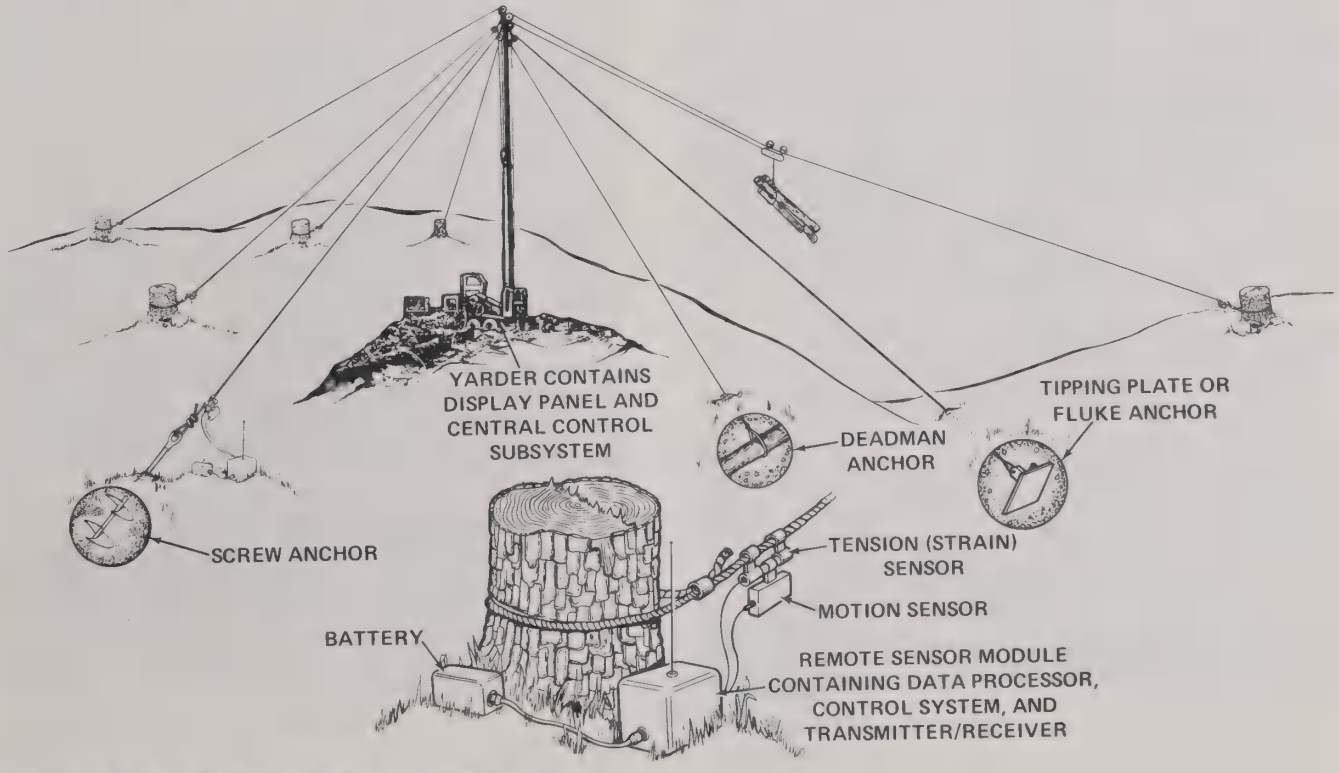
Motion and strain data, collected and processed by the microprocessor located at the anchors by the remote units, is transmitted to the central system (at the yarder) where anchor integrity is calculated and displayed. Anchor condition is reported in qualitative terms by color-coded LED's, and quantitatively in various engineering units (anchor stiffness, damping, impedance).

A 37-month full-scale development contract for the development of a SEAS, has been entered into with Foster-Miller, Inc., of Waltham, Mass. Major contract items include Dynamic Testing and Model Development (DT), Soil Test Equipment and Methods (STEM), Anchor Test Equipment (ATE), and the SEAS.

Dynamic testing is being undertaken to gain an understanding of the dynamic behavior of cable logging systems and the loading regimes experienced at the anchors. Results will be used to further model development and validation and provide design criteria for other contract items.

An analytical model of cable logging systems is being developed. The model will be used to predict anchor loading and will serve to optimize anchor installation. Early model results will be used to support design work on other tasks.

Soil Test Equipment and Methods (STEM) will be identified or developed so that the logger or logging planner may make an on-site assessment of soil characteristics and choose the optimum substitute anchor arrangement for that site. Anchor Test Equipment (ATE) will be identified or developed to test the holding capability of prototype substitute anchors, during anchor development, by subjecting the anchors to loads identical to the loads identified during dynamic testing. The SEAS developed will consist of substitute anchors, anchor proof tester, anchor installation equipment, soil test equipment, transportation equipment, and user documentation.



Substitute anchors and Early Warning Anchor Failure Detection System for cable logging transportation systems.

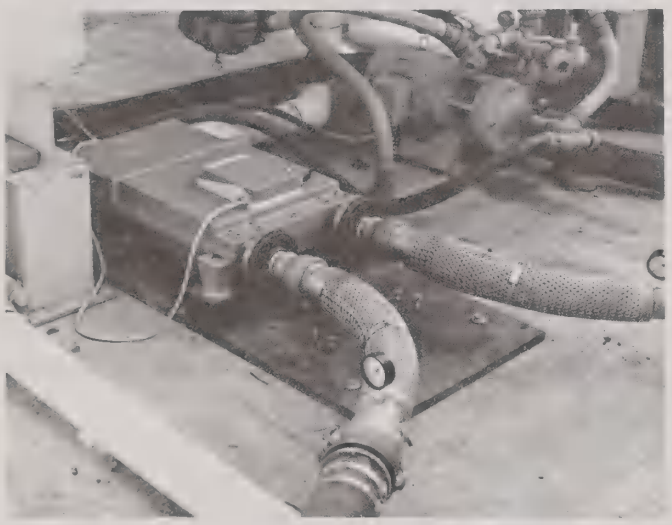
Fire Retardant Measurement System/Flow Meters

An accurate and reliable means of measuring quantities of fire retardant slurries loaded onto airtankers is required to insure that they are not overloaded and also to assure just compensation to fire retardant contractors. Flow meters, tank gage systems, and aircraft weighing systems tried in the past have proven insufficient. A new mass flow meter has been identified and shows much promise as a retardant measurement system.

The meter is a nonintrusive mass flow meter that measures mass flow (it meters weight rather than volume) by electromagnetically sensing the angular displacement of a vibrating, U-shaped flow tube. The displacement is caused by Coriolis forces developed in the vibrating flow tube as fluid moves into and out of the flow tube. The displacement signal produced is electronically processed to indicate mass flow.

Two meters of the 2-inch line size have been installed and undergone operational testing in California and Oregon. The meter has shown a season-long accuracy of better than 1 percent. Accuracy is not adversely affected by fluid viscosity, temperature, and density, The 2-inch size meter will pass 500 gpm, with a 35-psi pressure drop.

A 3-inch meter will soon be available. This larger size meter will pass more fluid with a lower pressure drop.



Retardant flow meter measures pounds of fire retardant pumped into airtanker by monitoring Coriolis force-induced flow tube displacements.

Analyzing and Optimizing a System for Aerial Fire Ignition Helitorch

In the past few years, aerial ignition, particularly with the gelled-gasoline helitorch, has become commonplace in Federal and State land management agencies and private industry. The helitorch has been proclaimed by some as the greatest advance in fire management technology in a decade.

The helitorch is an industry-developed item, tested and evaluated by Missoula Equipment Development Center, Missoula, Mont. Early testing was done on the Angeles National Forest, Mt. Baldy Ranger District. It was used to burn-out decadent old-growth chapparal brush stands, long inaccessible to wildlife. These stands are a major hazard from wildfire to the homes in the foothills of Los Angeles County, Calif. During the testing, burning-out was done in strips from ridge tops downhill and within the confines of prescription weather and fuel moisture.

The Forest Service operates about 50 gelled-gasoline helitorches, and other Federal agencies, State agencies, and private industry operate another 150.

Helitorch being used on the Angeles National Forest.

Mountain-Climbing Backhoe/Grapple

Many National Forests have slopes ranging from 35 to 100 percent that preclude the use of conventional equipment in carrying out effective land management programs. Hand labor has been used, but is expensive and limited in scope so many of the more difficult areas are not fully managed and utilized.

Two European manufacturers have recently introduced to the American market hill-climbing backhoes that can operate on slopes up to 100 percent. The Menzi Muck is made in Switzerland the Kaiser in Liechtenstein. These machines offer a unique new answer to the age-old problem of using mechanical equipment effectively and efficiently on very rugged and difficult worksites. They cost between $80,000 and $100,000, depending on accessory equipment. SDEDC has conducted tests on both machines over the past 3 years to determine their adaptability to do Forest Service work. The Center now owns a Menzi Muck. When equipped with the proper accessories, these machines can perform various engineering, reforestation, and construction tasks on steep slopes.

The machines can carry and operate attachments besides a backhoe, including grapple, swivel grapple, feller-buncher, air drill/hammer, rotary cutter (possible for fireline construction where tractors cannot go), and many shapes of buckets.

The Center has tested the Menzi Muck machine on six National Forests and found it to be a versatile, productive piece of equipment for working at sites in mountainous terrain that are inaccessible to other equipment. Work done during the tests included: Digging test holes to find subsurface materials to aid in cost analysis and design of forest road structures; placing large boulders to improve fish habitat in a remote canyon bottom; excavating a wildlife watering hole in a remote area; bunching, piling, and loading slash into a chipper from steep clearcuts; constructing cross-drains in a road fill; locating and cleaning out large culverts; and preparing sites for tree planting.

Menzi Muck loading slash into a chipper.

The Kaiser X5M "Spyder" walking down to clean out a sand filter.

The Center's Menzi Muck 5000 T2 excavating to drain sag ponds on a landslide.

Missoula Equipment Development Center

The Missoula Equipment Development Center is located at Fort Missoula, a military reservation just west of Missoula, Mont. Currently there are about 50 separate projects being worked on at the Center. These projects are divided into 10 programs. Range management is one of the program areas.

This year's work in our Range Program has already been covered by the workgroup chairman. I would like to briefly discuss five projects currently under development in our timber program.

Spot Site Preparation Equipment

In 1976 the Center conducted a survey to identify timber management equipment needs. The lack of equipment for removing competing vegetation from selected spots on steep slopes ranked as one of the top five problems. Accomplishing spot site preparation on steep slopes has become a serious problem because aerial logging methods have made it more feasible to work on such slopes. Also, land managers are increasingly concerned about compaction caused by the heavy ground equipment used for site preparation. The goal is to make available the equipment timber management personnel need to do spot site preparation on steep slopes.

In FY 1980 a selected group of Forest Service timber management personnel met to define the problem and set development criteria. The Center was assigned the task of improving or developing spot site preparation equipment in five categories: (1) Cable yarder operated; (2) dozer-mounted; (3) handtools; (4) thermal; (5) chemical. A market and literature search was conducted to determine the availability of equipment that could be used in the five categories. Typical problem areas were visited to verify development criteria. To begin the development effort a contract was awarded for the construction of a lightweight, truck-mounted cable yarder.

Clearwater yarder.

In FY 1981 the yarder was delivered. Two cable-operated scarification implements were built and tested. In FY 1982 two additional cable-operated implements were designed, built, and testing began. Site preparation handtools were sent to six regions for testing. Also, front- and rear-mounted scalpers for crawler tractors were built and tested.

In FY 1983 final work on cable-operated implements will be done. After testing and final modification, drawings and specifications for the construction of cable-operated implements will be completed.

Cable operated spot site scarifier.

Spot site preparation handtool.

Front-mounted dozer scarifier.

Center personnel met with an ad hoc committee representing reforestation experts from various Forest Service units. The committee laid out the project goals and prepared a development schedule. The first major effort in the project was to mount a tree shaker on a crawler tractor.The unit was successfully tested on the Winema National Forest, Oreg., in FY 1981 and 1982. This unit is designed to work in roadless areas.

A shaker with a 30-foot telescoping boom for truck-mounted, roadside shaking, was also fabricated and tested in FY 1982. The testing indicated that a truck-mounted shaker with a long reach can produce many bushels of cones along the roadside, quickly and efficiently. In FY 1983 a progress report was written to describe the work done to date. Drawings were prepared for the cat-mounted shaker. A totally new slip-on, truck-mounted shaker was designed and will be fabricated and tested before the end of the fiscal year.

Rear-mounted dozer scarifier.

Crawler tractor-mounted tree shaker.

Wildland Cone Harvesting Equipment

To meet expanding reforestation programs, new equipment and techniques are needed. One of the greatest needs is to provide seed that is adapted to the sites to be reforested. To provide the greatest compatibility between seed stock and site conditions, harvesting cones in wildlands is often the only alternative. Rough terrain, thick underbrush, steep slopes, and the widely dispersed and hard-to-reach nature of the cone crop make wildland cone harvesting difficult. The goal is to develop safe, efficient methods of harvesting cones in wildlands and report these methods to field reforestation personnel.

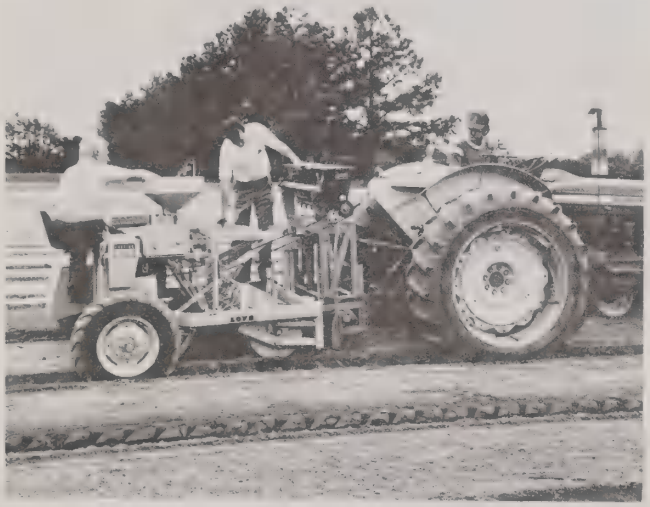
Truck-mounted tree shaker.

Mycorrhizae Inoculum Applicator

The symbiotic relationship of mycorrhizae fungi with tree seedling feeder roots is well established. Scientists recognize that mycorrhizae fungi are an element in the health and growth of many plants on certain soil types. Although this information is available to nursery managers, the benefits of artificial inoculation of mycorrhizae are not being realized because of the lack of proven application techniques and equipment. The goal is to help make equipment and equipment-use techniques available to nursery managers to enable them to artificially inoculate their nurserybeds with mycorrhizae fungi to enhance seedling growth and vigor.

Work began on the project when Center personnel designed and built a mycorrhizae applicator to field test four methods of incorporating mycorrhizae fungi into nurserybeds. The machine was tested at nurseries in the Southwest in 1980. The best method was selected and an operational applicator incorporating that method was fabricated. The machine was tested, modified, and retested in the South in 1981 and 1982.

In FY 1983 the project will be completed by assisting State and Private Forestry personnel to implement applicator use at selected locations in the South. Assistance will be given to the manufacturer that plans to market the applicator. A report will be written to describe the development and the performance of the applicator.



Mycorrhizae inoculum applicator.

Seedbed Thinning Equipment

Field personnel involved in reforestation work are asking for larger diameter tree seedlings with better developed root systems. This requires less dense growing conditions in the seedbed. Incorrect germination data for higher-than-expected survival, can cause seedling density to be too high. By thinning, density is controlled and uniform spacing is achieved. But most thinning is done by hand, which is expensive. The goal is to make available equipment to nursery managers that will enable them to thin seedbeds effectively and economically.

Center engineers consulted nursery managers to determine requirements for seedbed thinning equipment. A market search revealed several commercially available thinners that potentially could be modified to thin seedling beds.

A commercially available beet thinner was purchased, modified, and tested in FY 1980. Testing and additional modifications were made in FY 1981. The results showed that the tractor-mounted thinner can substantially reduce thinning costs. However, it cannot be used under all conditions or on all tree species. While testing the mechanical thinner nursery managers suggested that a hand-operated thinner be tested. A prototype was fabricated and testing began. Testing and modification of both systems continued into FY 1982. Because the hand-operated thinner performed so well, Forest Service nursery managers recommended that no further work be done on the mechanical thinner.

Instead, Center attention focused on the hand thinner. A production study was conducted at a Forest Service nursery that showed the hand-operated thinner cut costs (as compared to hand thinning) by 8 to 1.

Ten improved hand-operated thinners were built at MEDC in FY 1983. They will be sent to Forest Service nurseries for summer work. This implementation effort and the preparation of construction drawings and specifications will complete the project.

Hand-operated thinners.

Miniyarder

Increasing demands for wood products and energy emphasize the need for better utilization. Although utilization has improved, the volume of unused residues and other potential salvage material is still large. In the short run, more complete recovery is the most effective way to add to the timber supply.

The goal was to make available a small, relatively inexpensive yarding machine to demonstrate to land managers that it offers another alternative for reducing the fire hazard with the added benefit of making the residues available for other uses.

To achieve this goal, the Missoula Center developed a miniyarder that is making it possible to cost-effectively yard light slash, thinnings, and small stems from steep slopes. This small yarder operates on terrain and soils that may prevent conventional ground skidding or where larger cable systems are inefficient and uneconomical because of the materials' small size.

The Center developed this small yarder for the Bitterroot National Forest, Mont. The Bitterroot Miniyarder is a compact, two-drum skyline yarder that weighs 1,600 pounds fully rigged. Despite its size it can pull 2,000-pound loads at line speeds of about 160 feet per minute.

Small yarding systems like the Bitterroot Miniyarder, which enable private industry to economically yard and use residues, have numerous benefits. The primary ones are: (1) energy and raw material savings that result from improved utilization; (2) increased time frames and flexibility in treating slash that results in labor economics; (3) reduction in air pollution and related scheduling problems; (4) reduction of resource losses resulting from delays in returning land to production; (5) reduction in resource losses that occasionally result from escaped prescribed fires.

To implement this technology, the Center has produced an Equip Tips, brochure, and conducted many demonstrations for wood products industry representatives and independent loggers. A short Project Record film is also planned. Fabrication drawings are available on request. To date, 11 Bitterroot Miniyarders are operating on National Forests in Montana, Oregon, Washington, Idaho, Alaska, and in the South. Miniyarders are being demonstrated in New Mexico and the Eastern Region.

Bitterroot miniyarder.

Invited Speakers and Papers

BLM's Rangeland Rehabilitation Equipment Pool, Vale, Oregon

Cliff Hiatt, *BLM, Vale, Oreg.*

The BLM's Rangeland Rehabilitation Equipment Pool, operated by the Vale District of BLM, Vale, Oreg., contains 70 rangeland drills and 19 brushland plows. These drills and plows are available on loan to any BLM District on a first-come, first-serve basis. After BLM needs are met, this equipment is available to other U.S. Government agencies.

The equipment can also be loaned to farmers and ranchers through agreements with the Soil Conservation Service. These agreements require the rancher to pay $1.50 per acre, plus cost of repairs caused by abuse. The SCS retains $.25 and contributes the remaining $1.25 to the BLM equipment pool fund. Before equipment can be moved out of the Vale yard, the rancher must have a signed agreement on file, or bring one with him.

Through the many years of working with this range rehabilitation equipment, many modifications and changes have been made that have improved seeding with less downtime. This is important as seeding time is generally limited, and weather may cause delays.

The Vale District keeps a movement form on all the equipment coming in or leaving the Vale yard. This movement record is designed to show ownership, property number, destination to and from, cost of repair, and who hauled the equipment. A work order form on each drill and plow is also kept. This form aids in keeping cost records and inventory control.

The Vale District can transport the range rehabilitation equipment to and from seeding locations with all mileage and per diem being paid by the receiving agency. The Vale District has one high-boy trailer which can haul six drills and two carts as well as several bobtail trucks that can haul two drills and one cart.

The Vale District has a well-equipped shop and trained personnel to work on this range rehabilitation equipment. As many as 140 drills have been repaired in one season. A $75,000 inventory of drill and plow parts is maintained. Vale will furnish repair parts for field repair only to other BLM units, because Vale's budget is not large enough to supply routine repair parts. There is no repair charge to BLM Districts as funding for the drill and plow equipment pool program are provided directly to Vale District for this purpose.

The Vale District range equipment personnel have conducted six training seminars in the past 2 years. These seminars are designed to familiarize range conservationists and supervisors with range rehabilitation equipment. Many favorable comments have been received about these seminars. Vale will provide a training seminar on range rehabilitation equipment to BLM Districts on request.

Ecological Considerations in Designing and Selecting Reclamation Equipment

Willis G. Vogel, *Forest Service Northeastern Forest Experiment Station, Berea, Ky.*

Abstract
It has been recommended that the Vegetative Rehabilitation and Equipment Workship identify and promote a better understanding of the ecology of the land to be treated as a first step in designing and modifying equipment. The precept also is applicable to the selection of existing equipment. This paper describes where and how ecological principles may relate to and be considered in the design, modification, and selection of equipment for reclaiming and vegetating disturbed lands.

Introduction
It is apparent that ecological principles should be considered in the reclamation and revegetation of surface mines and other disturbed lands. Equipment is used in most reclamation activities, but the relationship of ecology to the design, modification, and selection of equipment for reclamation often is overlooked. Equipment usually is selected for its convenience and economy. That which is on hand or readily accessible most likely will be used. Even where equipment is designed, modified, or acquired specifically for reclamation purposes, it usually will be evaluated mainly for its mechanical and economic attributes in accomplishing those purposes.

The Steering and Exploratory Committees of the Vegetative Rehabilitation and Equipment Workshop (VREW) have suggested that greater emphasis be placed on ecology in the workshop's equipment development program. Specifically, they recommended that VREW identify and promote a better understanding of the ecology of the land to be treated as a first step in designing and modifying equipment. This precept also should apply where existing equipment is selected and promoted for a given rehabilitation or reclamation objective. One difficulty with this recommendation is that it may not be readily obvious where or how ecology relates to the development and selection of equipment. This paper discusses some ecological concepts and factors and their importance in designing, modifying, or selecting equipment for reclaiming and vegetating disturbed lands.

Ecology and Ecosystems in Reclamation
Ecology is defined as the study or science of the interrelations between living organisms and their environment. A system or complex of organisms and environment that form a functional unit in a defined segment of space and time is called an ecosystem. Human manipulation (e.g., surface mining) can drastically alter segments of or entire ecosystems.

Living Organisms
Most ecosystems include a variety of macro and micro flora (plants) and fauna (animals). Systems such as the tall grass prairie and Appalachian mixed hardwood forest include a large variety and number of flora and fauna. Systems that result from surface mining and similar manipulations are not as complex, at least temporarily, as those that existed before mining because the native microorganisms and macroorganisms are destroyed, displaced, or reduced in number. Reclamation of these lands is largely an attempt to restore organisms on them. In some cases, reclamation is an attempt to restore a land use (ecosystem) similar to the one that existed before mining; in others, a new or different land use is initiated.

Organisms of most concern in the reclamation of drastically disturbed lands such as surface mines are (1) herbaceous and woody vegetation, (2) microorganisms, (3) soil fauna, and (4) wildlife.

The Environment
The main components of the environment that are of concern in reclaiming disturbed lands are (1) climate and (2) geologic materials or substrate. Climatic factors that should be considered in reclamation and in equipment design and selection include: (a) total, type, and distribution of precipitation; (b) seasonal and limiting temperatures; (c) light or solar radiation; (d) seasonal and limiting humidity; (3) wind direction and velocity; and (f) evaporation potential. Geologic factors to consider are: (a) chemical and physical characteristics of overburden or spoils and native soils; (b) physiographic features of the site such as slope angle and length, aspect, relief, and size of disturbed area; and (c) surface and subsurface hydrologic patterns.

Human Interactions in Ecology
Ecology blends into the social sciences because humans are part of and their activities significantly affect most ecosystems as we know them. For example, economic considerations more than environmental ones usually dictate how much a mining company will spend in reclaiming a surface mine. Sometimes, the most expensive reclamation procedures may also be the least ecologically sound. This can be observed from the consequences of some of the laws and regulations governing surface mining and reclamation that seemingly were written without consideration of ecology. For example, new problems with revegetating mined lands are resulting directly or indirectly from some reclamation laws and regulations such as those that require the return of steep slopes to approximate original contour, topsoiling with B and C horizons, replacement of soil horizons that contain fragipans, and planting of woody species in established grass sod.

Equipment and Ecology Considerations

It is difficult to discuss reclamation equipment separately from reclamation practices and techniques, especially where ecological considerations are concerned. The following discussion will focus mainly on equipment and ecological factors to consider in choosing, designing, or modifying such equipment.

Environmental Factors

Climatic events and conditions cannot be significantly altered by human manipulation. However, some of the effects and consequences of climate on geologic materials and organisms can be altered or modified with equipment. For example, one of the major concerns in reclaiming surface-mined lands in arid regions is to apply surface treatments that hold precipitation on the site where it will be of most benefit to plant growth. The Hodder gouger, basin blade, land imprinter, and contour furrower are examples of equipment designed for that purpose. These implements create depressions and furrows that hold and conserve precipitation (rain and snow) and reduce runoff and erosion when precipitation is abundant. Their use for controlling erosion is most important on slopes. The depressions also reduce soil erosion caused by wind. Soil and air temperatures at the bottom of gouger basins are several degrees warmer than the surrounding air; this causes plant growth to begin a week or two earlier than normal. Results with these implements have been mostly positive and illustrate that several ecological factors were considered in their design. However, some types of soils seal over in the bottom of depressions made with these implements. Impounded water is lost, mostly by evaporation, and the soils crack when they dry. This illustrates the need to consider all ecological factors before selecting equipment for a particular reclamation job or site.

Climatic, topographic, and soil conditions may influence the design and selection of seeding equipment. Hydroseeders, for example, were designed for seeding and mulching steep slopes. A hose attachment allows the hydroseeder even greater versatility in seeding hard-to-reach places. The hydroseeder is popular in the humid and mountainous Appalachian region where broadcast seeding is a standard practice and sometimes successful even on poorly or unprepared seedbeds. Seeding by such methods on similar seedbed conditions in drier regions could result in failure. Where slopes and other site conditions permit, seeding with a deep-furrow drill may be a better choice in arid regions. The drill will place seed close to available soil moisture and the furrows may help to hold runoff and snow. But one also should consider edaphic and climatic conditions that cause soils to slough and furrows to fill in. Where this occurs, seed is buried so deep that the tiny seedlings cannot emerge. Such conditions may occur more easily on spoils and minesoils where organic matter and soil structure is lacking.

Mulching can enhance revegetation by reducing the adverse effects of temperature, solar radiation, raindrop impact, and wind on the geologic materials and subsequently, on plant growth. Mulch also helps moisture infiltrate the soil, retards evaporation, and helps control wind and water erosion. Mulching equipment should be capable of applying the kind and amount of mulch adequate to accomplish these objectives in a given climatic and topographic situation. For example, applying wood-fiber and cellulose mulches with a hydromulcher (hydroseeder) is a standard practice in vegetating steep slopes common to surface mines in the humid Appalachian region. Hydromulching is impractical for vegetating large leveled areas because of the greater time required to apply the mulch compared with other types of mulches, and because of the higher cost of wood-fiber mulches compared with other materials that may be available locally. In addition, a convenient source of water is needed for hydromulching. A mulcher such as the modified tub grinder can apply straw, hay, or other materials at least 10 times faster than the hydromulcher can apply wood-fiber or cellulose mulches.

The rate of hydromulch considered adequate in humid situations may be insufficient to protect seedings on mined lands in arid regions. More important, the practice of mixing seed and hydromulch together can be disadvantageous in dry climates because some of the seed will be held off the soil by the wood or cellulose fibers. The primary roots of these seed stand little chance of penetrating into mineral soil before they dry out. In arid regions, seeding in a separate operation before mulching is recommended even where hydromulching is used.

Some types of mulches require specialized equipment to hold them in place. Straw and hay can be "tacked" in place with asphalt emulsion applied by an attachment on the power mulcher. These mulches can be pressed into the soil with a disk-like implement called a Krimper. Straw crimped across slope (on contour) will provide a better deterent to erosion caused by runoff than straw tacked with asphalt or other soil binder.

Spoils and soils require special consideration because they are the substrate for growth of plants, soil fauna, and soil microorganisms. The chemical and physical characteristics of spoil and soil have been the focus of much of the research, demonstration, and legislation on mined-land reclamation. Some equipment probably was designed with consideration for soil characteristics. An example is the rangeland drill for seeding in stony soils and rippers, subsoilers, and chisel plows for fracturing compacted soil layers. But such consideration is sometimes overlooked when existing equipment is chosen for reclamation purposes. For example, earth-moving equipment and methods developed primarily for road construction have been used to replace and reconstruct prime farmland soils on surface-mined areas. Scrapers are used to remove and replace the soils in much the same manner as in building a roadbed. This results in compacted soils that restrict plant growth and offsets the benefits of saving and replacing topsoil. The compaction problem can be alleviated with rippers, a practice that also is very expensive. An alternative method of soil movement and placement is hauling the soil in trucks, dumping it in windrows on the reclaimed site, and spreading it with low-pressure crawler tractors.

The standard farm disk often is used to prepare a seedbed and to attempt to break up compacted soil and spoil. This implement is not adequate for the latter task because its use usually results in a shallow disturbance that produces a limited

rooting zone for plants. A heavy-duty offset disk would penetrate the soil somewhat more deeply. A ripper or chisel plow usually would be the best choice, but these implements can pull buried rocks to the surface—a situation that is not always compatible with the planned land use. A combination of deep ripping and shallow disking may prepare a better seedbed than either method alone. Tillage implements should be chosen for the specific site to meet the reclamation objectives.

Steep slopes cause problems in preparing seedbeds, incorporating lime and other amendments,and, in some areas, with seeding and planting. Equipment designed to handle these problems is needed; however, if such equipment were designed to be used only on steep slopes, the cost of design and construction might be prohibitive due to a limited market. The main ecological concern is that any form of tillage must be done on contour so as to not induce soil erosion. On some types of mining operations, implements that could be towed along the slope from a bench at the top of the slope may serve this purpose. Conventional farm tractors with extended double rear wheels can move along the contour on 3:1 and possibly even 2.5:1 slopes, but turning must be done on a more level area.

"Tracking in" with a crawler tractor that repeatedly goes up and down a slope is a standard practice for preparing seedbeds on steep slopes. Perhaps the efficiency of the operation could be increased with an attachment such as the land imprinter that would track in a swath that is at least as wide as the tractor. The steep-slope seeder scarifier and the containerized-shrub injection planter attachment for a backhoe (now being developed by the San Dimas Equipment Development Center) will satisfy some of the needs in treating and vegetating short slopes. However, they will not satisfy needs on the long, steep slopes found on surface mines in some regions.

Lime required to neutralize extreme acidity in minesoils should be incorporated to a depth of at least 6 inches. A standard farm disk usually will not penetrate deep enough to accomplish this, especially on compacted or semicompacted soils. A heavy-duty offset disk or chisel plow is more suitable for deep incorporation of lime.

Living Organisms

Reclaiming disturbed lands is most often associated with the planting and seeding of grasses, forbs, shrubs, and trees that we believe will survive and grow in the environment of the disturbed site. Both native and introduced plant species are used, but species origin usually has little bearing on the selection of revegetation equipment. The characteristics of the seed and seedlings to be planted have considerable influence on selecting the type of equipment best suited for the job. For example, seeds of some plant species, including some of the most desired native grasses, are very light and fluffy and may not feed satisfactorily through rangeland drills, standard grain drills, and some grassland drills. However, modified feed mechanisms for drills are now available commercially.

Hydroseeders broadcast seed in a slurry or mixture with water. Fertilizer and wood- or cellulose-fiber mulch can be added to the slurry. Plant species to be seeded may be a factor to consider in choosing the type of hydroseeder, or in choosing between a hydroseeder and other types of broadcast seeder. Seeds of some species can be severely damaged when they pass through the pumps on a hydroseeder, especially seeders with centrifugal pumps and bypass agitation. Hydroseeders with gear pumps and paddle agitation cause less damage. The longer the seed is in water before spreading, the greater the damage. Germination of pubescent wheatgrass seed circulated continuously for 2 hours through a centrifugal pump was reduced to about 1 percent, but to only 59 percent in a hydroseeder with a gear pump and paddle agitator. Adding wood-fiber mulch reduced damage to the seed with the centrifugal pump, but made little difference with the paddle agitator.[1] Obviously, not all types of seed will be similarly affected. Seed of some species, especially large seeded grasses, can be severely damaged; however, legume seeds with hard coats and even grasses such as buffalograss will benefit from seed coat scarification caused by abrasion in the hydroseeder pumps.

The rapid reestablishment of native trees and shrubs on surface-mined land is a concern in some regions. Hand and machine planting of 1- to 3-year-old, bareroot nursery stock is a standard procedure in humid and semihumid regions. But in arid and semiarid regions, environmental stresses, especially moisture stress, often preclude successful establishment of small seedlings by such methods. Irrigation is one way to help seedling establishment. Design of irrigation equipment and management are critical components of an irrigation system. Consideration must be given to the moisture requirements of different plant species, the quality and quantity of available water, and the erosion hazards, infiltration rates, and other physical and chemical properties of the substrate.

Another approach is transplanting trees and shrubs large enough to withstand these environmental stresses. This can be done with a mechanical tree spade and auxiliary transport equipment. Ecological factors to consider before selecting a tree spade include type of plants (those with long taproots may not transplant successfully), type of soil (stony soils may interfere with blade drop), slope angle (should be less than 15 percent), and type of spoil (chemically and physically suited for the species being transplanted). The major limitation to this transplant method is an economic one.[2]

Seedlings of trees, shrubs, and some native forbs have been grown in containers or tubelings in greenhouses for transplanting on disturbed lands. Advantages claimed for containerized seedlings include more rapid and year-long production of seedings, extended planting period, and no transplant stock (as occurs with bareroot nursery seedlings). Also, growth media inoculated with beneficial microbes and nutrients can be transplanted with the seedling. An ecological consideration in the planting of containerized seedlings is the size of the container, type of container, and planting equipment. Some

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[1] Kay, Burgess L. 1972 Hydroseeding limitations and alternatives. Univ. Calif. Agric. Exp. Sta. Agron. Prog. Rep. 43. 3 pp.

[2] Brown, Darrell. 1977. Handbook, equipment for reclaiming strip mined land. USDA For. Serv., Missoula Equip. Dev. Cent., Missoula, Mont. 50 pp.

containers are too small for good plant survival, especially in arid regions. Tube containers at least 2.5 to 3 inches in diameter and 12 to 18 inches long are recommended to help overcome this problem.

An even more serious problem with many containers is that the seedling's root system is severely constricted and forced to grow circularly into a tightly knit plug. When outplanted, the development of a normal rooting pattern from this plug may be delayed or prevented. In some cases, adverse effects of the root form may not become obvious until after the tree or shrub planting has been declared successful.

The containers selected should force root growth into a more desirable pattern. Mechanical tubeling planters have been developed, but some modifications may be helpful, such as a means of loosening the soil instead of compacting it around the planting hole, especially in fine-textured soils. For steep slopes where mechanized equipment cannot be used, a suitable hand tool such as the "Swede hoe" or muck scoop should be considered for planting tubelings.

Reestablishing functional populations of microorganisms (bacteria, fungi, etc.) associated with plants and soils is important for the rapid and sustained growth of vegetation on disturbed lands. Diversity and population levels of microorganisms usually are low on spoils but should be more abundant in native soils. Thus, replacing topsoil on disturbed areas appears to be one way of quickly reestablishing microorganisms. However, stockpiling soil for long periods before replacement has an adverse effect on populations of these organisms, partly because their energy source (organic matter or host species) is destroyed and consumed. The soil environment in terms of poor water relations and soil atmosphere may also be detrimental to microorganisms in stockpiled soil. Removing, transporting, and placing topsoil with as little disturbance and delay as possible would seem least detrimental to microorganisms as well as to soil fauna.

The dryland sodder and similar modified front-end loaders are examples of equipment designed to remove, transport, and place chunks of topsoil and native plant materials intact, and in one operation. Costs would be prohibitive to replace sod and pads of native plants over entire areas of disturbed land, but this equipment is useful for establishing islands of macroorganisms and microorganisms that could migrate (pioneer) onto adjacent minesoils. To enhance development of the microorganisms on the minesoils also requires that a source of energy be supplied, either artificially from organic amendments such as sewage sludge, bark, or straw, or naturally from vegetation grown on site.

Specialized equipment designed to salvage and chip woody vegetation could have ecological significance for reclaiming mining sites in forested areas where the woody vegetation usually is dozed over and burned or buried ahead of or during the mining operation. Converting the woody vegetation into chips could provide material for mulching new seedings and for controlling dust on haulroads. Also, wood chips could be allowed to partially rot before being spread and mixed into the minesoil. The rotted wood aids retention of water in the soil and is an excellent source of energy for mycorrhizal fungi and other beneficial microorganisms, and for some species of soil fauna. A self-propelled chipper that approaches this need has been developed by the USDA Forest Service's Southern Forest Experiment Station.[3] The chipper cuts woody vegetation and trees up to 12 inches in diameter and blows the chips into following trucks. There are slope limitations for its use and chipping by such methods currently is not economically attractive to most mining operators.

Interference by established herbaceous ground cover is an ecological problem in reforesting disturbed sites. One popular solution is to kill some of the herbaceous cover with herbicide either before, during, or after planting tree seedlings. Better equipment for accomplishing this probably needs to be designed or existing equipment modified, though there are environmental considerations in the use of chemicals. Mechanical removal of herbaceous cover is feasible in some situations; the modified fireplow was effective for this purpose in western trials. A recent modification of the Hodder gouger will enable it to remove patches of sod from stands of seeded, introduced herbaceous cover species so that native plant species can be sowed, planted, or given a chance to volunteer in the gouged spots. An alternative on relatively level and gently sloping areas is to seed on contour strips of herbaceous species that alternate with unseeded strips planted only to trees. The system needs to be tested; if feasible, equipment could be designed or modified to perform the herbaceous seeding, fertilizing, and tree planting or seeding at the same time. The unseeded strips also would increase the opportunity for volunteer seeding of native species.

[3] Information available from Don Sirois, Southern Station's Forestry Sciences Laboratory, Auburn, Ala.

Conclusion

Ecology seemingly has been considered, either consciously or unconsciously, in designing and modifying many of the pieces of equipment used in reclaiming disturbed lands. One of the best examples is with equipment designed to configure the soil surface for greater conservation and efficient use of precipitation. Failure to consider ecological factors seems to occur most often in the selection of equipment that is already available. Reasons for this are most often related to economics and convenience, and familiarity to the user. Unfortunately, what appears to be less costly initially may in the long run cost more due to reclamation failure and the need to repeat the practice or treatment. Equipment on hand or that with which a person is familiar will more likely be selected. For example, a standard farm disk often is used in situations requiring a heavy-duty disk, chisel plow, or ripper. A contrasting example is backblading with a giant dozer for seedbed preparation where a standard farm tractor and disk would be adequate and would prepare a better seedbed—and probably at less cost. In some cases, the equipment might be suitable but is not used properly. An example is working up and down slope instead of on contour, or working the soil when it is too wet or too dry.

Some of the revegetation problems related to equipment selection result in directly or indirectly from the requirements of reclamation laws and regulations that seemingly were not based on ecological considerations. One of the most prevalent problems, at least in the East, is excessive soil compaction resulting from the use of inappropriate earth-moving equipment and procedures in replacing topsoil. Some of these problems can be overcome with better selection and more judicious use of existing equipment. Practices such as planting trees in conjunction with herbaceous cover probably could be expedited with the design or modification of equipment.

Acknowledgment

I thank Stuart Bengson, Clay Kolar, Ron Younger, Bill Berg, Earl Aldon, Tom Richards, Richard Hodder, and Clark Ashby for suggestions and comments on this paper.

The Savory Grazing Method.

Allan Savory, *SGM Range Consultants, Albuquerque, N.Mex.*

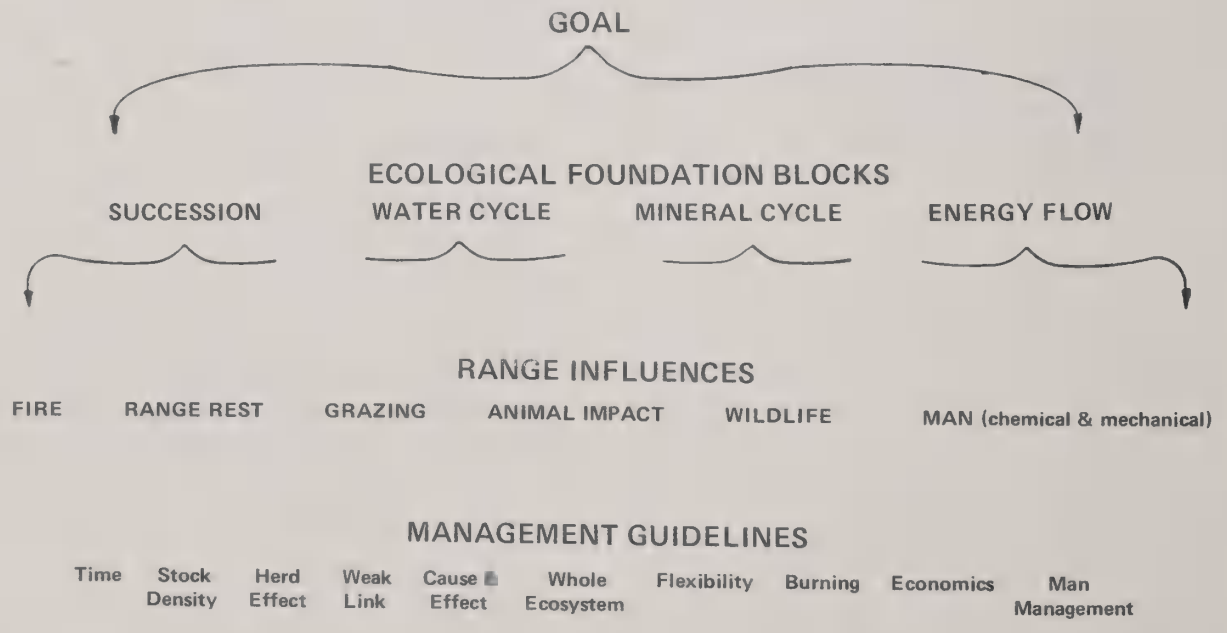
The Savory Grazing Method (SGM), or holistic resource management, is a way of managing all of the resources in any ecosystem (the community of animals, plants, and the environment with which it is interrelated) to produce a desired goal. Whatever the goal, it has to be based on the management of four ecological foundation blocks (see chart). These ecological blocks, or principles, are built to the level necessary to achieve the goal by selective application of a series of range influences (see chart). The range influences are, in turn, manipulated through a number of management guidelines (see chart).

With SGM, the ecosystem is managed holistically. For many of you, "holistic" may be a new word. It is derived from "holism," which refers to the theory that in any ecosystem, the components (including man) function together as a whole, but are meaningless individually unless viewed in relation to the whole. When you apply SGM, you will manipulate the various components that make up the range ecosystem to achieve a desired end result on the whole. Where conventional range management is based almost entirely on plant management, SGM is based on the management of the "whole," including precipitation, sunlight energy, soils, plants, animals of all forms, biological succession, financial and labor resources, seasonal and daily changes in growing conditions, and a host of other factors. It cannot be applied as a system as it has to be tailored to each situation and each season, and yet it is universal in its application.

SGM is particularly well suited to application on multiple-use public lands either with or without livestock. Common uses would be in watershed management, wildlife management, and timber management. SGM can be applied as a diagnostic tool and to the subsequent management of such areas. It is not necessary that there be any fencing or livestock involved. Where livestock are available as a range influence, management of other resources can be enhanced.

Many conventional range management techniques such as range reseeding, brush clearing, and mechanical soil treatment can be used with SGM as they are an integral part of it. When used with SGM these techniques become both more effective and more economical.

Tragically, the range profession is copying terms and fencing designs from SGM and reducing it to assembly-line mentality "cell systems," "short duration grazing systems," etc., that will never produce the successes that SGM does in resource management and which mostly follow developmental phases of SGM of some 15 years ago.



Savory Grazing Method or holistic resource management.

How Can VREW Tie with MARC?

Lauri Zell, *Mining and Reclamation Council of America, Washington, D.C.*

As you can see from the meeting agenda, I have been asked to address the question, "How can VREW tie with MARC?" Before I answer this, let me say on behalf of the staff and the membership, of the Mining and Reclamation Council of America (MARC) that we are pleased to be given this opportunity to tell you about our organization and some of our recent research activities. Our two organizations share an important common goal: Providing a forum for exchanging ideas to enhance the development and dissemination of technology used in improving coal mining and reclamation. As Craig Rupp said at last year's VREW meeting, "Technology transfer, or getting the knowledge communicated and out to where it's needed and can be used, is a tremendous challenge that may in itself create some changes." We agree that this is a challenge which all facets of the industry must strive to achieve together.

Recognizing this need for unity to meet the legislative, regulatory, and technological challenges in the coal industry, the Mining and Reclamation Council (MARC) was established in 1977 as the national trade organization representing the surface coal mining community. The council was formulated shortly after the passage of the Surface Mining Control and Reclamation Act, beginning with a core group of coal companies convinced there was an important gap for MARC to fill in Washington, D.C.—the need for a national spokesman for the surface coal mine operators in the Congress and in the administrative agencies. Since that time, we've grown significantly, listing over 300 coal companies and 31 State and regional associations throughout the country among our membership—ranging from the small operators to some of the largest producers in the nation. By utilizing the strength of industrywide support, MARC provides a united front on major issues of common interest, enabling coal to assume its proper role as a vital energy source for the future.

MARC is working toward a clearly defined national energy policy that stresses increased production and utilization of America's vast coal reserves. The council believes coal can be mined with total integrated environmental protection through development and demonstration of reclamation and pollution control technology. MARC was founded on two basic principles: (1) the technical aspects of surface mining are separate and distinct from those of underground mining and mining of other minerals; and (2) coal utilization will increase significantly in the coming years and most new production will be from surface mines. These two factors, coupled with the growing awareness that more rapid exploitation of domestic coal reserves is clearly in the national interest, signaled the need for a strong organization to present the concerns of the surface mining industry.

For the past 5 years, MARC has been working to meet its goals to establish coal as the keystone of America's energy supply; to achieve a healthy regulatory atmosphere that encourages expanded production and utilization of domestic coal; to organize the industry into a political force through its members at the grassroots level; to serve as the industry liaison with Congress, the administration, and Federal agencies; and finally to improve the public image of the surface coal mining industry.

Within this broad mandate, one of MARC's primary strategic objectives is to aid in the development of relevant research and transference of results of coal mining studies to the industry as expeditiously as possible. Therefore, MARC often conducts private and government-directed research projects utilizing the expertise of its members. These members provide an essential link between Washington bureaucrats' and legislators' perceptions and direct field observations of the operating experts in the surface coal mining industry. Effective coordination of MARC's members for various projects insures that research and development objectives correspond to specific company experiences and problems.

Five years have passed since President Carter ended the decade-long debate over enactment of Federal legislation for the surface coal mine industry. Today, all major coal producing States now have Federal Government approval to implement their permanent regulatory programs. The Reagan administration's modification of the "State Window" provision should afford these States considerable latitude in reshaping the Federal requirements to accommodate the local conditions as Congress had intended. These developments, plus the likelihood that the proposed Federal regulatory changes will be finalized by the Office of Surface Mining within the next 2 months, will cause State agencies and coal producers to seek innovative alternatives for cost-efficient regulatory compliance to avail themselves of this needed flexibility.

It is within this context that MARC endeavored to determine the research needs of the industry through a nationwide assessment.

The unique composition of MARC's membership and its ability to tap into the numerous segments of the industry, created a logical position for MARC as the organizer of a survey-research effort. MARC coordinated meetings in six States, representing the three major coal regions of the country, to gather research recommendations. Invitations were sent to all sectors of the coal industry, including producers, consultants, equipment manufacturers and other coal-related vendors, academic researchers, and government personnel. In fact some of you may have participated in our meetings in 1981 and 1982 in Kentucky, Pennsylvania, Alabama, Tennessee, Indiana, and Colorado. These diverse groups assembled throughout the country with one common goal: to develop a comprehensive list of practical and theoretical research needs that would help to mitigate the operational and regulatory-related deficiencies.

The results of the nationwide assessment provide a documented frame of reference for Federal and private sector decisionmaking regarding priority research needs. Although the participants focused on specific constraints on current production and reclamation technology, many research recommendations have significant implications for regulatory and legislative policymaking as well.

Two policy recommendations deserve special attention since they were frequently addressed by participants nationwide. The first is the need for more efficient technology transfer. The importance of information exchange for new research breakthroughs cannot be overstated—it is critical if sound decisions are to be made regarding mining and reclamation technology. Standard data bases are insufficient; common regional, Federal, State, and private data base networks must be developed. The industry recommended these networks be based on scheduling, engineering, and environmental data and shared with all partners in energy development. Such a computerized system would serve as the national clearinghouse for government, academic, and industry research, and could be built upon the success of more specialized information repositories such as VREW's.

The second significant policy suggestion concerns the need for developing a regulatory environment that encourages the use of experimental practices during mining and reclamation activities. Recommended research includes investigating methods to allow for separate experimental practice permits and ways to develop performance bonding regulations allowing for segregation of experimental test plots from the overall permit area. The industry believes these procedures would prevent suspension of permits that include provisions for long-term research activities in such areas as revegetation. When these problems are resolved and experimental research becomes more widespread, the results of such work can then be entered into the proposed data network.

Turning to specific production and reclamation technology suggestions, the research proposals focused on five major topics: hydrology, sediment control, reclamation, air quality, and blasting. For the purposes of this presentation I will briefly highlight the priority projects identified in the East, Midwest, and West. I encourage you to obtain a copy of the complete study from our office for a more thorough understanding of the detailed recommendations. The complete title is *Determining the Research Needs of the Surface Coal Mining Industry*, July 1982; cost $15.

In the East, coal concerns recommended research efforts be directed toward developing operating techniques and treatments of acid mine drainage (AMD) applicable concurrent with mining and/or reclamation. Two aspects of foremost priority are techniques for predicting acid formation and no- or low-maintenance methods of preventing formation of neutralization of AMD.

The second research priority identified was the study of watershed management and sediment control. Many operators have difficulties complying with Federal sediment control standards, indicating that available methods for predicting sediment loss are inadequate. The universal soil loss equation does not accurately reflect mining conditions. Thus, there is currently no totally reliable method of estimating sediment loads for designing sedimentation ponds and other facilities.

The third priority for research focused on standards for successive revegetation, including prime farmland productivity concerns. Specific study issues include work on species selection, vegetative management systems and the effects of required handling methods on prime farmland productivity levels.

Looking at midwestern research priorities, participants emphasized the need for alternative nonstructural sediment controls related to better topsoil handling, and retaining or preventing the destruction of topsoil so reclamation of farmland can be more effective. Research suggestions in this area include equipment adaptation to reduce soil compaction, use of soil amendments, investigation of tillage practices, topsoil segregation and handling and seedbed preparation.

The second set of priorities centered on prime farmlands. Many different reclamation research projects were suggested for seedbed preparation, productivity, and long-term maintenance. In most cases the participants highlighted new equipment needs. Other important issues included developing guidelines for post-mining land uses and productivity, and establishing better reforestation practices after an analysis of the approximate original contour regulation is completed.

The next important midwestern recommendation was to conduct research to determine which factors are large contributors to the return of normal biological conditions in a stream after reconstruction. This assessment should include studying physical elements of the stream in terms of flow, morphology, channel shape, split configuration, and revegetation. This work can be utilized to show that, with appropriate mitigation practices, fish and invertebrates will recolonize altered channels.

The last two issues receiving top priority ranking in the Midwest include a study of the remining issues related to prime farmland productivity requirements, and development and refinement of mitigating techniques for cleaning aquifer systems.

Finally, western mine operators prioritized sediment control issues first. Research is needed to examine the quality of existing background water before and after mining. Western regional baseline data pertaining to surface water runoff should be analyzed to verify if there is a discrepancy between the effluent standards and natural runoff. The second major research area is that of alternative sediment control measures. Such measures have the potential to provide more than adequate environmental protection at lower costs. Research should demonstrate and quantify the effectiveness of alternative measures, develop performance standards for sediment control that recognize varying natural stream conditions and develop cost information that can be used in sediment control planning.

Alluvial Valley Floor (AVF) issues ranked second in priority for western research efforts. Operators specified that a comprehensive study needs to be performed to provide for a preliminary classification system of AVFs. A cost-effective methodology for AVF determination should be coupled with this study. Another related research need is to determine the effect subsidence from underground mining might have on an AVF; this includes the effects on flood plains, as well as water tables and prime farmlands. While present methods of analysis do exist, more research was recommended to improve the state-of-the-art. Such work would hopefully lead to a higher percentage of resource recovery, as well as provide a cost-effective means of predicting underground mining operations' effects on important surface features, such as AVF's.

The third critical research area relates to the determination of cumulative hydrologic impacts. Work should focus on both the development and refinement of improved methodologies to determine cumulative hydrologic impacts, and the development of comprehensive data bases and models which are set up and calibrated for basins where active or proposed mines are located.

Lastly, western coal interests recommended revegetation studies be placed on the priority list. This issue is very important, as it relates to the economics of reclamation and total costs, including such factors as performance bond release. Of particular concern is that general vegetative parameters traditionally used to describe a vegetative community, both in pre- and post-mining inventories, don't necessarily reveal much about the qualitative aspects, such as suitability for proposed post-mining land use. Participants suggested that a quantifiable or systematic method should be developed to include the use of livestock or wildlife carrying capacity as a determinant of reclamation success.

Now that the comprehensive report, *Determining the Research Needs of the Surface Coal Mining Industry*, is circulating throughout the industry, and making its way into the hands of the key Congressional and regulatory policymakers, it is clear that research should be undertaken in many areas so increased coal production and utilization will not remain constrained by lack of improved technology. Further, since the coming months will be important ones for the future of the surface mining act and its regulatory structure, we must take advantage of the report to document our resulting research and development concerns.

MARC is hopeful that the industry, the States and the Federal decisionmakers will carefully scrutinize our recommendations, not only for the purpose of funding research, but to develop an understanding of the issues that can be incorporated in the reformation of the act in the future. Research will assist in laying the groundwork for the much-needed emphasis on site-specific flexibility in the act. And in the regulations, by increasing the levels of technology while ensuring that the same, or better, levels of environmental protection are maintained.;

Coordination Of Mined Land Reclamation On National Forest System Lands

Wayne Patton, *Minerals and Geology Staff, Forest Service, Washington, D.C.*

In recent years, mined land reclamation has become a focal point for the Vegetative Rehabilitation and Equipment Workshop (VREW) and many attendees at this and other meetings are from the mining industry. I believe that this is healthy, and I know that the expertise represented by VREW can be of great help to the Forest Service minerals effort as well as the mining industry in performing their roles relative to mined land reclamation.;

The Minerals and Geology Staff, along with representatives from the Bureau of Land Management, State agencies, and the Office of Surface Mining, has the job of managing mined land reclamation on National Forest System lands. We see to it that mined land reclamation is planned and carried out properly. I'll give you an overview of what this reclamation is, how it is accomplished, and how VREW is involved.;

Mined land reclamation is not to be confused with restoration. Landscapes are put back into roughly the same shape and productivity level that they were in before mineral development. However, postmining land uses do not have to be thought of only as a replacement of original conditions. The opportunity exists during the reclamation planning and execution phases for enhancement of the site if other interests are willing to finance the extra cost and can intercede early enough in the development of the project operating plan. An example of this kind of enhancement would be a duck pond on a site where none existed before.

The land manager's job along with that of the minerals specialist is to foresee the whole pattern of events and help the participants play their roles at the appropriate times. Reclamation is well-suited to teamwork among specialists, and is an active part of the planning process right from the beginning. The life cycle of each minerals project is mapped out by the minerals manager. The location, size, and conformation of the project over time is estimated and included in the forest plan as part of the planning process. These plans, then, form the basis for the budget and workforce planning process. The Forest Service passes the information in the land plan (prescriptions for end land use and future management) to the mineral industry. This information is then used in a joint effort by industry and government to develop operating plans for the mineral projects throughout the life cycle. Reclamation plans are a part of the plan of operation and any enhancement relative to end land use must be included at this point. Some changes in reclamation plans can be made during operations but can only be minor in scope for reclamation is a large undertaking for most mineral operations and cannot be easily changed. The minerals specialist develops a plan for each major mineral project or group of smaller projects. Future developments are predicted by interviewing lessees to get some idea of their plans. Before each phase in the mineral project life cycle, careful plans are made by the mineral specialist relative to makeup of teams of specialists needed at that point in time. Using these plans, budgets are formulated for the following 2 to 3 years. This planning can effect the makeup of the interdisciplinary teams and coordination is needed between the mineral specialist and other disciplines. Necessary contract work is planned during this phase, also.

At this point, we are going to look at several aspects of a typical minerals project. The magnitude of some minerals projects has been a surprise for the Forest Service. Until a few years ago the Forest Service had never been involved with a world-class molybdenum operation like the Quartz Hill project in Alaska or a large, open-pit coal mine like the Black Thunder operation on the Medicine Bow National Forest in Wyoming. The Forest Service is critically short in some areas of expertise associated with management of mineral projects such as engineering knowlege of conveyor belt systems and management of large-scale reclamation efforts.

A minerals project consists of activities inside as well as outside the claim or leasehold, such as buildings, parking lots, roads, conveyor belts, pipelines, and transmission lines. Therefore, reclamation of mineral operation involves more than just mine spoils, pits, or settling ponds; the entire operation is involved.

A project can be very different at various points in its life span. The major milestones in the life cycle of a mineral project are as follows:

- Prospecting.
- Exploration.
- Development.
- Production.
- Close down.
- Postmining activities.

Reclamation takes place during and after each phase with the exception of prospecting.

So, reclamation expertise and equipment needs are very different, depending on the stage of operation we are dealing with. The plant materials expert would be involved with several working groups made up of individuals with different skills, depending on the stage of operation. Numerous mineral commodities, some with special legal requirements, are mined on National Forest System lands in a wide variety of locations using various extraction techniques.

Therefore, each type of mineral project has its own combination of opportunities, problems, and constraints for the specialists working on reclamation plans. Many different kinds of equipment, are needed, from small, load leveling types for use on steep slopes to large systems used for strip mine reclamation. In addition, many different kinds of expertise are needed, from knowledge of high attitude operations encountering permafrost to reclamation in the Sonoran Desert. This, of course, is where VREW is of great help to the minerals specialist. As our reclamation specialists are faced with problems unique to the mineral industry, increasing numbers of requests will be given to VREW for special equipment and expertise. Some of the equipment has already been developed and all we need is some knowledge about it through VREW technology transfer. We are making an effort to get copies of VREW publications to our minerals specialists, Forest Service-wide.

In summary, it is critical for minerals specialists to coordinate with those having expertise in reclamation. Minerals specialists have the job of coordinating reclamation efforts with the other disciplines. However, plant materials and soils specialists should contact minerals experts relative to on-going and future mineral projects and future reclamation needs and make plans to supply necessary expertise at least 2 to 3 years before the expertise is needed.

The time for plant materials and soils experts to become involved in the reclamation effort for a mineral project is at the first phase when baseline information is collected and plans are made (jointly with industry) regarding postmining land use. Reclamation expertise is built into the plan of operation for the mineral project. The reclamation specialists carry out operational supervision and monitor operating plan compliance. The final involvement comes during reclamation field work at the end of a mineral project and management of the postmining landscape for the selected end land use. The key to this whole process is early involvement in the reclamation planning process.

Some mineral projects are huge so as to dwarf even the largest projects which have been associated with National Forest System lands. The sheer size of the these projects necessitates stepped up efforts in the mined land reclamation program and coordination with VREW. There will be increased opportunity for participants at this meeting to get involved in the very challenging opportunities surrounding mining and other mineral efforts on National Forest System lands.

Equipment Development and Test Funding

Planning and Budgeting Procedure

For many years the "Range Reseeding Committee" was an informal group, meeting each year to exchange information on work of mutual interest and to develop project proposals for work to be done by Equipment Development Centers or field units. The proposals were written, estimated for cost, and finalized "on the spot." Informal but it seemed to work!

Today there are demands being placed on us to plan in detail 2 years in advance, and in general 5 to 10 years ahead. This does take away some of the informality of the operation and dictates the need for a more organized approach to the preparation and submittal of project proposals. Figure 1 shows a plan by which we can meet our budgeting dates. It provides a mechanism whereby the Equipment Development Centers can stay with the budget process of the Forest Service.

The other aspect of our planning procedure is a more uniform format for project proposals. Figure 2 is a suggested guideline for proposals. Following this guide will help all concerned in preparing and reviewing proposals. It should make the flow of information more efficient and provide a much better story for those who must analyze needs, prepare programs, and assign priorities.

We hope that everyone associated with the Vegetative Rehabilitation and Equipment Workshop will cooperate in this more formal approach. It should be an aid to everyone. If any questions arise or there is a need for help in this process, call the Centers or the Washington Office.

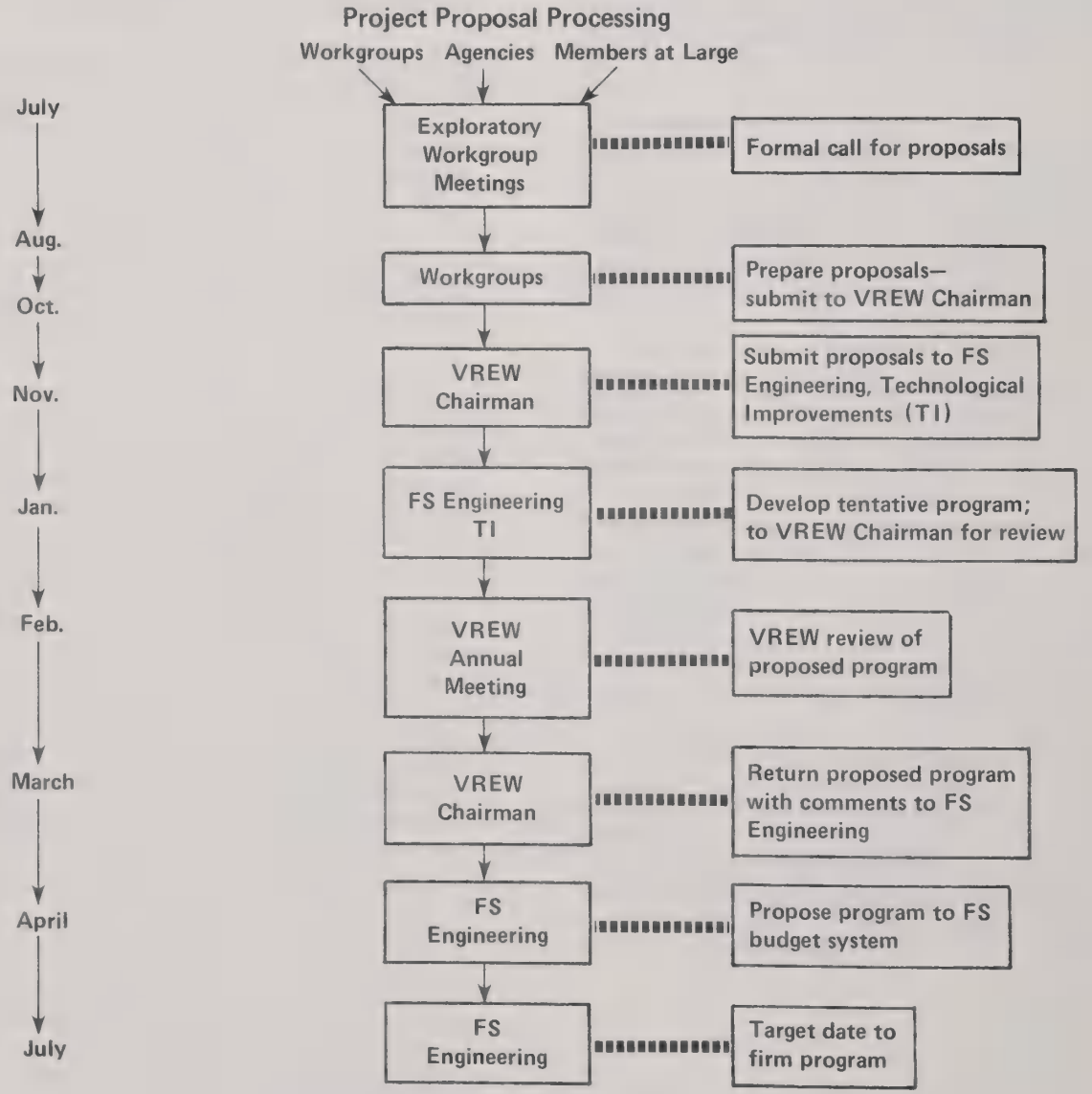


Figure 1.—Project proposal processing.

(PROJECT PROPOSAL FORMAT)

EQUIPMENT DEVELOPMENT AND TEST PROJECT PROPOSAL FOR FY _____

ED&T Project No. (Leave Blank)
Date _____
Primary Interest: _____

_____
(TITLE)

- *(The title should be brief and indicative of project objectives.)*

PROBLEM STATEMENT AND OVERALL OBJECTIVES

- *(State the problem and describe how the work is currently being done. Tell what equipment, materials, or methods are used, and why change or improvement is needed. Show significant advantages and potential savings, such as: increased production or efficiency, property or human hazard reduction, reduced maintenance, and public demand or reaction.)*

- *(State the overall objectives. What is to be accomplished or what is to be achieved by this project?)*

- *(Include amendments to the problem statement and overall objectives, if necessary (for completion by the Development Centers for applicable continuing projects only). The statements of the original problem and objectives should not be changed. If there is a change in emphasis, add revised problem statements and objectives here.)*

SPECIFIC REQUIREMENTS

- *(Distinguish between minimum requirements and those which are desired but not essential. Describe features required or specify performance characteristics. Where more information will be needed but cannot be furnished, list items that should be explored.)*

PRIOR DEVELOPMENT

- *(Briefly describe work already completed or underway which is related to this project. On new projects, this work will generally have been done by other persons or organizations or under other equipment development projects. For a continuing project, tell when it started and briefly state major accomplishments, and actions planned for completion in the current fiscal year. Reference the overall project time frame and total cost estimate if previously made and if applicable, prior reports and publications.)*

PROJECT ORIGIN

- *(Show the name, organization, etc. of persons originating the project and preparing the project proposal.)*

Figure 2.—Format for project proposal.

FY 1983 Program

Missoula

	Project	*Amount*
TE02D15	Technical Services, Range	$ 10,000
0E02D19	Range Habitat Tape	7,000
7E72D22	VREW Information Workgroup Support	20,000
		$ 37,000[1]

San Dimas

	Project	
TE02D17	Technical Services, Range	$ 15,000
0E01D40	Water Pumping Systems Improvements	66,000
		$ 81,000[1]

[1] Additional interagency funding as listed below was added to that shown above after the beginning of the fiscal year:

USDI - BLM	$12,000
USDI - BIA	5,000
USDA - Extension Service	3,500
	$20,500

Range Publications and Drawings

Below are titles of reports on a variety of range rehabilitation topics, as well as a list of range equipment fabrication drawings. These materials have been produced by the Forest Service Equipment Development Centers at Missoula (MEDC) and San Dimas (SDEDC) and may be of interest to workshop members. Single copies of the reports are available without charge by writing to the appropriate Center. Some drawings are available without cost also; there may be a small charge for others.

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The list of publications includes *Equip Tips,* concise reports dealing with new equipment, new uses for equipment, and similar topics; *Equipment Development & Test (ED&T) Reports,* documenting major development studies; *Project Records,* describing the technical details of development work, including procedures, results, conclusions, and recommendations; a number of special reports, ASAE papers, and service manuals are listed under "Other Reports."

Equip Tips

Bitterroot Miniyarder for Light Forest Materials, May 1983—MEDC

Small Yarder for Steep Terrain, May 1981—MEDC

Resource Publications, Dec. 1980—MEDC

Proper Use of Fusees, Feb. 1980—MEDC

Improved Aerial Ignition System, Jan. 1980—MEDC

Protecting Western Conifer Seedlings, May 1979—MEDC

Steep-Slope Seeder for Roadside Slope Revegetation, Feb. 1979—SDEDC

Improved Method for Joining Plastic Pipe, Dec. 1978—MEDC

Seed Dribblers (revision no. 1), July 1977—SDEDC

Spray Boom Assembly, July 1972—SDEDC

Plastic Pipe Laying Machinery, Jan. 1966—SDEDC

Browse Seeder with 20-inch Scalpers, Jan. 1965—SDEDC

ED&T Reports

Catalytic Converter Exhaust System Temperature Tests, Feb. 1977—SDEDC

Slash . . . Equipment and Methods for Treatment and Utilization, April 1975—SDEDC

Clearing, Grubbing, and Disposing of Road Construction Slash, Oct. 1976—SDEDC

Roadside Slope Revegetation, June 1974—SDEDC

Flexible Downdrains, Jan. 1974—SDEDC

Tractor Attachments for Brush, Slash, and Root Removal, Jan. 1971—SDEDC

Results of Field Trials of the Tree Eater, Jan. 1970—SDEDC

Forestland Tree Planter, Sept. 1967—SDEDC

Pine Seed Drill, Sept. 1967—SDEDC

Project Records

Evaluation of the Pettibone Slashmaster Model 900 for Site Preparation in the Lake States, Feb. 1983—SDEDC

Dryland Plug Planter, Dec. 1982—MEDC

Tree-Planting Machine—How Much Can You Afford to Pay for One?, June 1981—SDEDC

Sod Mover Bucket, Dec. 1980—MEDC

Tree/Shrub Planter for Roadside Revegetation, Oct. 1980—SDEDC

Observations on Operations of the Pettibone Hydro-Slasher PM 800, Feb. 1980—SDEDC

Basin Blade for Disturbed Land Revegetation, Nov. 1979—MEDC

Plastic Tubes for Protecting Seedlings from Browsing Wildlife, July 1979—MEDC

Mulching-Tilling Equipment for Soil Conditioning, Jan. 1979—MEDC

Evaluating Methods for Joining Polyethylene Pipe, Dec. 1978—MEDC

A Transplant System for Revegetating Surface Mined Lands, Nov. 1978—MEDC

Grapples for Forest Residues Concentration and Removal, Oct. 1978–SDEDC

Field Equipment for Precommercial Thinning and Slash Treatment, July 1978–SDEDC

Modified Hodder Gouger, Dec. 1977–MEDC

An Investigation of Equipment for Rejuvenating Browse, Aug. 1977–MEDC

Survey of High-Production Grass Seed Collectors, Jan. 1977–SDEDC

Remote Sensing for Big Game Counts, Dec. 1976–MEDC

Evaluation of the Vermeer Model TS-44A Tree Spade for Transplanting Trees on Surfaced Mined Land, Feb. 1976–MEDC

Wildlife Habitat Management Needs, Oct. 1975–MEDC

Using Heat for Sagebrush Control, Feb. 1972–MEDC

Other Reports

Development of a Containerized Shrub Injection Planter Attachment for a Backhoe–A Prospectus, Jan. 1983–SDEDC

Dryland Plug Planter–Operator's Manual, Jan. 1983–MEDC

History of the Vegetative Rehabilitation and Equipment Workshop (VREW) 1946-1981, Dec. 1982–MEDC

36th Annual Report–Vegetative Rehabilitation and Equipment Workshop, Sept. 1982–MEDC

Punch Seeder for Arid and Semiarid Rangelands–A Prospectus, Sept. 1982–SDEDC

Development of A Disk-Chain Implement for Seedbed Preparation on Rangeland–A Prospectus, Sept. 1982–SDEDC

Arid Land Seeder Development–A Prospectus, July 1982–SDEDC

Equipment for Containerized Tree Seedlings, July 1982–MEDC

Catalog for Hand Planting Tools, May 1982–MEDC

Sources of Seed and Planting Stock, Oct. 1981–MEDC

Sod Mover Operator's Manual, Feb. 1981–MEDC

Development of a Rangeland Interseeder for Rocky and Brushy Terrain (ASAE paper 80-1552), Dec. 1980–SDEDC

Equipment for Reforestation and Timber Stand Improvement, Oct. 1980–Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402; Request Stock No. 001-001-00563-1; $6.50.

34th Annual Report–Vegetative Rehabilitation and Equipment Workshop, Sept. 1980–MEDC

Modified Basin Blade–Operator's Manual, Mar. 1980–MEDC

Sodder brochure, Mar. 1980–MEDC

Basin Blade brochure, Mar. 1980–MEDC

Mulching-Tilling System brochure, Mar. 1980–MEDC

Transplanting System brochure, Mar. 1980–MEDC

Sprigger brochure, Feb. 1980–MEDC

Dryland Plug Planter brochure, Feb. 1980–MEDC

Revegetation Equipment Catalog, Feb. 1980–MEDC

Agricultural Engineer's Role in Rangeland Improvement and Rehabilitation Equipment (ASAE paper 79-161), Dec. 1979–SDEDC

Observations on Operations of a Residue Shredder and a Brush Harvester, Sept. 1979–SDEDC

33rd Annual Report–Vegetative Rehabilitation and Equipment Workshop, July 1979–MEDC

Front-End Loader Tree Spade–Manual Supplement, Feb. 1979–MEDC

35th Annual Report–Vegetative Rehabilitation and Equipment Workshop, Sept. 1981–MEDC (Available from National Technical Information Service (NTIS) U.S. Department of Commerce, Springfield, VA 22161 for $10.50 in paper and $4.00 in microfiche.)

Concepts–Sod Mover, Aug. 1978–MEDC

Aerial Burning Equipment for Plant Control, Feb. 1977–MEDC

Handbook–Equipment for Reclaiming Strip Mined Land, Feb. 1977–MEDC

Rangeland Drill Operations Handbook, BLM Tech. Note 289, Sept. 1976–SDEDC

Evaluation of the "Vari-Dozer," Feb. 1974–SDEDC

Investigation of Selected Problems in Range Habitat Improvement, Feb. 1974–SDEDC

History–Range Seeding Equipment Committee 1946-1973, Jan. 1974–MEDC

Results: 1972 Range Improvement Survey (27th annual Range Seeding Equipment Committee report), Feb. 1973—MEDC

Implement-Carrying Hitch for Forestry Use (ASAE paper), Dec. 1972—SDEDC

Efficiency and Economy of an Air Curtain Destructor Used for Slash Disposal in the Northwest (ASAE paper), Dec. 1972—SDEDC

Service & Parts Manual for the Contour Furrower Model RM 25, June 1970—SDEDC

Service & Parts Manual for the Brushland Plow, June 1968—SDEDC

Service & Parts Manual for the Rangeland Drill Models PD-10x6 and B-20x6, Aug. 1967—SDEDC

Other Publications of Interest to VREW

Private Water Systems Handbook, Midwest Plan Service, Iowa State University, Ames, IA 50011. $2.50

Water Systems Basics, DE/Journal, 522 North State Rd., Briarcliff Manor, NY 10510. $3.

Water Systems Handbook (7th Edition), Water Systems Council, 221 North La Salle St., Chicago, IL 60601. $6.

Water Well Handbook, Keith E. Anderson, Missouri Water Well and Pump Contractors Association, Inc., P.O. Box 517, Belle, MO 65013. $10.

Evaluation of Pumps and Motors for Photovoltaic Water Pumping Systems, David Waddington and A. Herievich, Solar Energy Research Institute. Available from National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22161. $3 microfiche; $5.25 printed copy.

Rangeland Drill, reprint from "Rangelands," vol. 4, no. 3, June 1982.

Glossary of Surface Mining and Reclamation Terminology, Bituminous Coal Research, Inc., 350 Hochberg Rd., P.O. Box 278, Monroeville, PA 15146 (412) 327-1600. $2.

Range Development and Improvements, 2nd edition, J.F. Vallentine. 1980, Brigham Young University Press, Provo, UT 84602. 545 pp. $18.95.

How to Build Fences with Max-ten 2-- High Tensil Fence Wire, U.S. Steel Corp., P.O. Box 86 (C-1424) Pittsburgh, PA 15230. $5 plus $1.50 postage and handling.

How to Design An Independent Power System, Terrance D. Paul, Best Energy Systems for Tomorrow, Inc., P.O. Box 280, Necedah, WI 54646, (608) 565-7200. $4.95.

From American Association for Vocational Instructional Materials (AAVIM) Engineering Center, Athens, GA 30602:

Planning for an Individual Water System, No. 600, $6.95

Planning Fences, No. 404, $4.25

Building Fences, No. 405, $4.25

(For orders less than $10 add $1 for postage and handling; for orders over $10 add 8 percent for postage and handling.)

Drawings at SDEDC

Pipe Harrow, RM1-01 and 02

Brushland Plow, RM2-01 to 22

Oregon Press Seeder Assembly (not complete), RM19-01 to 07

Plastic Pipe Layer Assembly, RM21-01 to 03

Reel for Laying Plastic Pipe, RM24-01

Contour Furrower, RM25-01 to 14

Rangeland Drill Deep Furrowing Arms, RM27-46 to 61

Steep-Slope Seeder, RM33-01 to 18

Demonstration Interseeder for Rocky and Brushy Areas, RM35-01 to 09

Drawings at MEDC

Sprig Spreader, No. 652

Sprig Harvester, No. 651

Dryland Sodder, No. 631

Tubeling Planter, No. 628

Basin Blade, No. 619

Horse Trap Trigger, No. 618

Mulch Spreader, No. 611

Tree Transport Container, No. 604

Tree Transplant Trailer, No. 602

Modified Hodder Gouger, No. 583

Dixie Sager and Modified Ely Chain, No. 568

Incendiary Grenade Dispenser, No. 522

Attendance at Annual Meetings

Meeting			Participants				
Date	*Place*	*Presiding Chairman*	*Federal Gov't*	*State Gov't*	*Private*	*Foreign*	**Total**
Dec 1946	Portland[1]	Joseph F. Pechanec	6	0	0	0	6
Dec 1947	Ogden[1]	" "	9	0	0	0	9
Jan 1949	Denver	" "	15	0	0	0	15
Dec 1949	Ogden[1]	" "	22	0	0	0	22
Jan 1951	Billings	" "	34	5	0	0	39
Jan 1952	Boise	A. C. Hull	45	9	0	0	54
Jan 1953	Albuquerque	"	75	15	9	1	100
Jan 1954	Omaha	"	63	8	3	5	79
Jan 1955	San Jose	W. W. Dresskell	62	10	4	1	77
Jan 1956	Denver	William D. Hurst	86	12	1	2	101
Jan 1957	Great Falls	" "	95	10	4	0	109
Jan 1958	Phoenix	Frank C. Curtis	87	9	3	0	99
Jan 1959	Tulsa	" "	84	5	2	0	91
Jan 1960	Portland	" "	98	10	3	3	114
Jan 1961	Salt Lake City	" "	123	11	14	2	150
Jan 1962	Corpus Christi	Frank Smith	58	5	7	1	71
Jan 1963	Rapid City	" "	52	6	1	0	59
Jan 1964	Wichita	John Forsman	61	10	5	0	76
Jan 1965	Las Vegas	" "	77	8	6	0	91
Feb 1966	New Orleans	" "	47	8	5	1	61
Feb 1967	Seattle	A. B. Evanko	58	10	4	0	72
Feb 1968	Albuquerque	" "	84	16	13	1	114
Feb 1969	Great Falls[1]	" "	46	3	12	0	61
Feb 1970	Denver	" "	81	8	11	0	100
Feb 1971	Reno	" "	74	6	15	2	97
Feb 1972	Wash., D.C.	" "	48	3	6	0	57
Feb 1973	Boise	" "	60	7	7	4	78
Feb 1974	Tucson	Bill F. Currier	61	12	10	14	97
Feb 1975	El Paso[1]	Stan Tixier	49	9	11	1	70
Feb 1976	Omaha	" "	50	17	12	0	79
Feb 1977	Portland	Vern L. Thompson	63	26	31	10	130
Feb 1978	San Antonio	" "	68	26	35	6	135
Feb 1979	Casper	Ted Russell	74	35	72	12	193
Feb 1980	San Diego	" "	97	44	88	21	250
Feb 1981	Tulsa	" "	56	35	111	16	218
Feb 1982	Denver[1]	" "	60	18	68	5	151
Feb 1983	Albuquerque	" "	119	82	96	9	306

[1]Meeting not in conjunction with Society for Range Management meeting.

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Washington, D.C.

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The Exploratory Committee is made up of the Steering Committee, workgroup chairmen, and appropriate Equipment Development Center personnel from Missoula and San Dimas.

1983 Workgroups

Note from VREW Chairman Ted Russell

Persons interested in participating in the activities of a workgroup are encouraged to write or call the workgroup chairman about their interest.

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